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NOTICE TO AUTHORS OF PAPERS

1. Forwarding Address. Papers intended for publication in THIS JOURNAL should be submitted to Neil E. Gordon, Editor, The Johns Hopkins University, Baltimore, Maryland.

2. Manuscript. The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

3. References and Footnotes. Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

4. Illustrations. Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

Photographs should have a gloss finish and should be at least post-card size—larger, if possible. Only prints which are unblurred and which show sharp contrast between light and dark areas can be satisfactorily reproduced.

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Tables should be inserted in the body of the manuscript at the proper place.

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JACOBUS HENRICUS VAN'T HOFF (1852–1911)

EDITOR'S OUTLOOK

IT IS said of the German universities that they not only search out and hold the most promising brains of the Fatherland but, discovering the intellectual giants of other countries, they use every inducement to tempt them across the border. Perhaps, then, it is one of Jacobus Henricus van't Hoff's titles to glory that Berlin sent three times to Amsterdam to entice him to leave his professorship in chemistry and to come to Germany. He came at last, much to the chagrin of the Amsterdam authorities.

Jacobus Henricus van't Hoff

For Amsterdam recognized his worth. Had he not opened out a new branch of science—stereochemistry? Was he not a pioneer in the broader field of the kinetics of chemical action? Scientists had awakened finally to the importance of his first publication, "The Structure of the Atoms in Space." His second book, "Chemical Dynamics," had proved even more remarkable. And in 1878, at the age of 26, he had been appointed to the chair of chemistry at the University of Amsterdam.

As Shelley, the poetic genius, attempted dangerous chemical experiments to the terror of his friends, so van't Hoff, the brilliant scientist, conceived in his youth a consuming passion for Byron, and once even wrote a poem. It is said that in his later years this affection for literature was almost completely submerged, the price paid no doubt by many great men of science for their absorption in research.

Van't Hoff made one trip to America in 1901 at the invitation of the University of Chicago. The university conferred an honorary degree upon him, as did Harvard at its commencement program. It was the privilege of Richards, who in 1914 became the first and (to date) the only American recipient of the Nobel prize in chemistry, to be host at Harvard to van't Hoff, who in the very year of his trip to America became the first recipient of the award in this field of science.

It is a striking fact that men who accomplish much do so often under physical handicap. Never very strong, van't Hoff fell a victim to tuberculosis. He fought it for several years, but finally succumbed in March, 1911. He is survived by his wife and four children.

Van't Hoff has been called the greatest Dutchman of our time. Physical chemistry, at least, acknowledges that his work, together with that of Arrhenius and Ostwald, has laid the foundation for its development.

SINCE the industries absorb by far the greater proportion of chemical graduates, it is natural and proper that chemical faculties should inquire just what training is best calculated to fit the student for

Training for the Industries

a place in the industrial scheme. For such information we can go to no better source than the industrial men themselves. At any rate, they know what training they desire in the men they hire and direct.

Strangely enough—or so it may seem at first thought—the industrialists, almost to a man, prescribe precisely the type of training which might be arranged for the student who intends to engage in purely academic pursuits. That is to say, they demand thorough training in the fundamentals of chemistry, they plead for more familiarity with physics and mathematics, a greater facility in the reading of French and German, and invariably for a better command of the English language. These demands sum up the consensus of opinion among industrial chemists, both as expressed by individuals from time to time and as revealed by the survey presented in this number by Kraus and Arnold.[1] There is almost unanimous agreement that specialized industrial courses are of little value, even though the student is definitely preparing to enter some specific industry.

There are, however, a number of old-established industries employing chemical processes which have heretofore operated almost empirically, but which are beginning to realize the necessity for stricter chemical control and for chemical research leading to further development. Such industries rest oftentimes in the hands of men of little or no chemical training. Among industries of this type, one often encounters requests for men trained in specific subjects. There is an unfortunate tendency to disregard the fundamental training of the candidate or to ignore the necessity of such training altogether.

This attitude cannot but lead to disappointments in the long run. In the first place, none but the most superficial training in any specific field of chemistry is possible unless the student has first been provided with a thorough general knowledge of chemistry and the allied sciences. In the second place, the most pressing need in such industries is for men who, with the aid of a broad general knowledge, will develop a new specialized chemistry.

It is true that many of the men employed for their specialized training make good. Some have, in addition, a good general knowledge; some repair the defects of their educations by further study. On the whole, however, a happy outcome of such an employment policy must be considered a matter more of good fortune than of good management. Colleges and universities which aspire to work in coöperation with the industries of their respective localities should consider it a duty to lay the facts before employers and to discourage rather than abet any tendency toward overspecialization in the training of chemists.

[1] See pp. 852–7.

FUTURE POSSIBILITIES IN THE UTILIZATION OF CELLULOSE*

Charles H. Herty, 101 Park Avenue, New York City

For forty years the chemical world has been busy with the ramifications of the coal-tar chemical industry, proceeding along definite scientific lines. We now find ourselves plunged rather suddenly into the Age of Cellulose. Vast industries depend upon cellulose as their raw material, yet, chemically speaking, their progress has for the most part been based upon empirical methods. Three great industries, the paper and pulp industry, the cotton-textile industry, and the lumber industry, representing a total capitalization of over $7,000,000,000, make use of cellulose in its natural state. During the year 1928 over 100,000,000 pounds of rayon (chemically treated cellulose) were produced in the United States alone, with a consequent enhancement in value of the raw material of some 1200 per cent. This chemical conversion of cellulose is the basis of such lusty infant industries as the new solvents and lacquers, artificial leather, insulating material, transparent glass, airplane dope, cellophane, and a host of other valuable products.

Fully cognizant of the difficulties besetting the path of a prophet, I do not hesitate to predict that the next decade is going to see new industries based on the utilization of cellulose whose influence on our industrial life will be tremendous. I base this prediction on experience. See what happened when once the structure of the benzene molecule became known. Although the first synthetic dyes were stumbled upon accidentally, all the wonderful developments in the coal-tar field, dyes, medicinals, photographic chemicals, synthetic aromatics, tanning materials, followed the revelation of the ring structure of benzene.

Today we do not know the structure of the cellulose molecule. We chemists write $C_6H_{10}O_5$, then we put it in a parenthesis and add a little n by way of admission that we don't know its actual structure. What wonderful possibilities are ahead for the research chemist!

Paper and Pulp Production

The paper and pulp industry is one of the major industries of the United States. According to the 1927 census it has a capital of $1,363,000,000, and its nearly one thousand establishments have an annual output of practically 15,000,000 tons valued at over $1,000,000,000. Whatever affects this industry therefore, for weal or for woe, is of national importance.

Every industry worthy of the name must be assured of a permanent source of supply of raw material. That this industry is aware of this is apparent from the statement on page 69 of the admirable report prepared

* Prepared from an address delivered at the Annual Meeting of the American Paper and Pulp Association, Waldorf-Astoria Hotel, New York, February 21, 1929.

at the request of the American Paper and Pulp Association by the U. S. Department of Agriculture, *Bulletin* No. 1241: "Only the growth of new crops of timber to replace present supplies can afford a basis for a permanent plan of operation." The bankers are awake to this fundamental requisite. Note the following statement from a publication of the National Bank of Commerce, *Commerce Monthly*, September, 1927: "The constant and continuous flow of raw material *in the same locality* (italics mine) is essential for the paper mill to be established on a permanently sound financial basis."

Sources of Cellulose

Where are the cellulose industries to find their future sources of supply? Cellulose constitutes the structural basis of the whole vegetable kingdom, and consequently at first thought one answers that it is readily available everywhere, and other economic factors are of more importance in deciding the location of your plants.

Cotton linters represent the purest form of cellulose from natural sources, but the great tonnage comes from our forests, the Northern spruce and the Southern pines. It seems to me the forestry people have made a great mistake in thinking about the future of American forestry solely in terms of trees. I think about a tree as a source of cellulose. The forestry people must remember, too, that when research now going on overcomes certain economic difficulties there is going to be a close race between the forest and the farm. Annual crops such as cornstalks, sugar-cane bagasse, peanut shells, and cottonseed hulls are logical sources of future supplies. When you think about the rate of growth of plants like bamboo and ramie there is no telling what may develop in the future in the way of a new supply of cellulose.

The paper and pulp industry naturally located first in our northern states and in Canada adjacent to the spruce forests. In this connection, however, I was struck recently by a statement attributed to Dean Howe, Faculty of Forestry, University of Toronto, who estimates that the depletion of Canadian forests amounts to 270,000 acres annually, while only 2000 acres are being planted each year.

Economic Independence

There is another angle to this matter. I am a great believer in national economic independence. In chemistry we learned this lesson thoroughly during the World War, and this nation made up its mind never again to depend upon an outside source for its necessary supply of chemicals. In the last ten years a revolution has been accomplished here in the United States in the development of our chemical industry. What signs are there that the paper and pulp industry need bear in mind this national policy?

Reports of recent conferences in Montreal regarding the exportation of wood from Canada to mills in the United States indicate no consideration for the comfort or welfare of the American manufacturer. Press reports contain the following significant statements: "It is known to the pulp and paper interests that the main reason the Federal Government does not put an embargo into effect is that it would interfere with colonization . . . . One section of the conference is reported to have held that an export tax on wood going to the United States would be better from the public point of view than an embargo." (Montreal despatch to the *New York Times*, November 20, 1928.)

Again, from the report of the meeting of the Canadian Pulp and Paper Association in the *Paper Trade Journal*, January 31, 1929: "The Honorable J. L. Perron, Minister of Roads of Quebec, representing Premier Taschereau, expressed the opinion that the solution of the present newspaper difficulties lay in the hands of the manufacturers, and he suggested that one way in which the association could help the Dominion was furtherance of a plan to prevent the annual export of 700,000 cords of pulp wood to the United States, and the payment of a just price to the settlers and small farmers who sell their pulp wood to the manufacturers." These Canadial officials seek rightly to serve their own people. So long as the paper and pulp industry is dependent upon outside sources of supply, situations over which they have no control and in which they have no determining voice are likely to arise.

Forest Reproduction

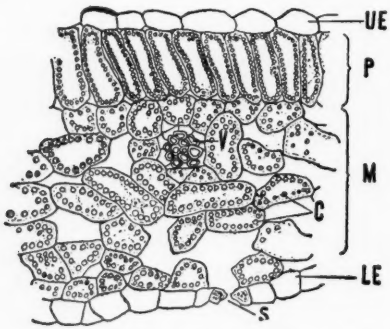
Now I am going to make another prediction. The great bulk of cellulose supplies of the future will come from forest reproduction, carried out under the best possible conditions. Some of these conditions are going to be provided by Nature, others will depend upon the research ingenuity of our chemists, and the consuming industries must do their part.

From the pulp and paper standpoint, it is my firm conviction that the best conditions are going to be found in the naval stores belt of the South, where it is not going to be a matter of waiting fifty or sixty years. Within ten or twelve years there is going to be a cash income available from two sources, naval stores production and utilization of the thinned out material.

Cellulose Formation

I am getting way ahead of my story. How is this cellulose upon which your billion dollar capitalization depends produced in Nature? What raw materials are essential and what factors affect the chemical reactions involved? Carbon dioxide and moisture from the air are the essential raw materials. The illustration following shows a cell section of a leaf. Note the upper epidermis, then the palisade cells, below these the meso-

phyll cells and at the bottom the lower epidermis. In this lower layer is shown one of the many stomata of the underside of the leaf, entry ports for the carbon dioxide and moisture. In the palisade and mesophyll cells are small bodies known as chloroplasts, wherein is localized the green pigment of the leaf. The chloroplast is in reality a marvelous synthetic organic chemical factory, where the carbon dioxide and water from the air, meeting the mineral matter in the sap from the roots of the tree are elaborated through the action of light and heat into starch and sugar, perhaps through the intermediate stage of formaldehyde, and eventually into cellulose. That is the basis of plant life. Animals feed upon plants. Men feed upon both. Human life therefore depends directly upon the efficient functioning of these tiny organic chemical factories. Chemical reactions in general take place better at higher temperatures. It is well known that the other factor fundamentally essential to plant growth is light or solar energy.



Courtesy of the Chemical Foundation, Inc.

VERTICAL SECTION OF BARBERRY LEAF

UE—Upper epidermis, *P*—palisade layer, *M*—mesophyll, *LE*—lower epidermis, *S*—stomata, *V*—vein, *C*—chloroplasts.

Rate of Tree Growth

Blessed with an abundance of sunshine and a moderate, equable climate, the South is the logical place for rapid tree growth. Confirmation of this is to be found in official data compiled by the U. S. Department of Agriculture showing the comparative annual yield of wood per acre on average soil at 30 years of age to be as follows:

	TONS
Northeastern Woods	
White Pine	1.3
Red Spruce	0.4
Southeastern Woods	
Slash Pine	2.9
Loblolly Pine	2.5
Short-Leaf Pine	2.0
Long-Leaf Pine	1.7

Here, again, I am willing to make a prophecy. If the U. S. Forest Service will go down to Southeastern Georgia and study the rate of growth of

BURNED LAND. NO REPRODUCTION; STUMPS NOT REMOVED

NATURAL REPRODUCTION OF SLASH PINE ON FIRE-PROTECTED PROPERTY
Separated from adjacent land shown in preceding picture by burned fire strip.

trees up to 10 or 12 years of age and compare these figures with like growth of Canadian spruce they will find that the difference is far greater.

According to the data in the preceding table the long-leaf pine of the South, commonly known as the Georgia or Yellow Pine, at 30 years of age on average soil grows more than four times as fast as the spruce of the more northerly regions. It is largely from this pine that you manufactured last year some 286,000 tons of kraft paper.

The comparative growth of slash pine is even more striking, however, more than seven times that of spruce.

TURPENTINE OPERATIONS (THIRD YEAR) AMONG SAPLINGS

The above photograph loaned by the Forest Products Laboratory tells the story of the growth of slash pine in a far more emphatic way than words of mine. This slash pine, also called Cuban Pine, is botanically known as *Pinus Cubensis*, or as *Pinus Heteraphylla* because there are sometimes two and sometimes three straws in each bundle. The habitat of the slash pine is a territory embracing more than 100,000 square miles, extending along the Atlantic and Gulf coasts from South Carolina to Louisiana, including the whole state of Florida.

As I look into the future I seem to see a far closer union between the

paper and pulp manufacturers and the naval stores operators of the South. It is my hope to be of some little aid in bringing these industries into closer relationship to their mutual advantage.

The Naval Stores Industry

This slash pine is the greatest of all producers of oleoresin, from which spirits of turpentine and rosin are manufactured. Following the weekly scarification, the oleoresin flows for a longer period than in the case of the long-leaf pine, and its slower crystallization permits rapid collection, thus avoiding undue evaporation of the volatile oil and discoloration of the rosin.

A most unexpected development has already taken place in the lower part of Georgia, where formerly magnificent forests of yellow pine existed. Perhaps this can be illustrated best by a bit from personal experience. In September, 1902, at a large gathering of turpentine operators I made my first public address covering the results of experimental work which clearly proved the desirability of substituting the cup for the box system of collecting turpentine. Following this address I was shown accurately compiled statistics which seemed to prove conclusively that in twenty years the naval stores industry of the South would become extinct. Yet, strange to say, the naval stores industry is still contributing its full annual quota to the world's wealth, and Georgia is today making more naval stores than any other three states combined. Where was the error in the statistician's conclusion? He overlooked the whole question of reproduction, and the successful use of young trees under the cup system of turpentining.

Dr. Mattoon of the U. S. Forest Service estimates that there are 30,000,000 acres of cut-over lands in the pine belt of the South, of low value and but poorly suited to agriculture. Through a mistaken notion that it was better to feed raw-boned cows a little fresh grass in the spring, this territory has been burned over each year: not forest fires in the usual sense among these pines with their long clean trunks, but the burning of the low wire grass, with the consequent destruction of billions of young pine seedlings. Wherever streams and roads and fallen logs afforded sufficiently extensive protection from these ground fires, a remarkable natural reproduction has taken place.

Pioneer Work

But real forest restoration in the South is going to result from the pioneer work of one man, Mr. Alex Sessoms, of Cogdell, Georgia. About five years ago he formed a firm conviction that ground fires could be kept out of the pine woods, and on a consolidated tract of 80,000 acres he has organized fire protection of the most modern type, including well-organized

PLOWED FIRE BREAK
This work costs approximately $40 per mile.

fire crews, fire breaks, either ploughed or intentionally burned, and lookout towers. On this protected land widespread natural reproduction, especially of slash pine, has taken place. Driving over this property recently my forester guide said: "Now I want to show you an ocean of saplings." Within a few minutes we saw almost as far as the eye could reach a veritable ocean of young pines, four to five feet in height. It was truly an inspiring sight. Other timber owners have followed the example of Mr. Sessoms and have joined in the organization of a Timber Protective Association which, under the laws of Georgia, will receive state aid in fire protection.

Mr. B. M. Lufburrow, State Forester of Georgia, estimates that 1,000,000 acres in South Georgia are under intensive fire protection, and the official

state records show that only one per cent of this territory was burned over last year. Nine lookout towers have been erected in this region, each serving about 75,000 acres. Some 750,000 acres of cut-over land in Florida are already under intensive fire protection. Mr. Lufburrow estimates that there are 15,000,000 acres of potential forest restorations in the turpentine belt of Georgia.

Early Income

An important factor is the availability of a cash income from naval stores production from young trees 6 to 8 inches in diameter which will later be taken out in thinning. Using the latest method, the so-called "split-streak" chipping on both sides of the tree, turpentine operations

can go on profitably while the timber trees are getting their growth.

Where does the paper and pulp industry fit into this picture? Under the prolific reforestation what utilization can be made of the thinnings from these young pine thickets? Here, again, is a source of quick income, for I believe they are going to form the continuous wood pulp supply of the future. I know full well the immediate reply, for I found it in the literature, in the *Bulletin* of the Department of Agriculture referred to in the early part of this paper. It is generally believed that this wood is "probably too resinous for consideration" by the sulfite process or by mechanical

Early Income from "Split-Streak" Turpentining of Tree to Be Removed in Thinning

processes, and that it is only good for the manufacture of kraft paper, and it is well known that there is already an over-production of kraft paper from Southern pines.

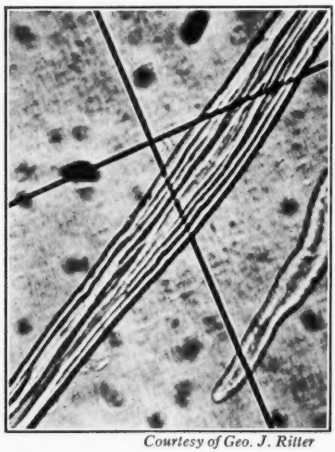
I am a lover of facts, and perhaps facts exist somewhere as to the amount of resin in these young slash pines, but I sought in vain, and have made inquiry of many persons who should be able to speak with authority on the subject. The replies have been admittedly only opinion, varying anywhere from 15 down to 5 per cent.

An Amazing Discovery

Recently I made up my mind to get the facts. Through the coöperation of Mr. Sessoms, who furnished the material, and Mr. J. S. Kloss, manager of the Brunswick plant of the Hercules Powder Company, in whose laboratory the work was done, some remarkable results have been obtained. Analysis of the sawdust from 30 young slash pines, varying from 4 to 10 inches in diameter, showed the following results:

Per cent resin, on dry basis (gasoline extract)	2.09
Per cent resin, on dry basis (alcoholic extract)	2.79

Upon receipt of this data, I wrote Mr. Kloss asking him to have the gasoline extract titrated with a standard solution of alcoholic potassium hydroxide and the amount of rosin in this extract estimated. Under date of February 8, 1929, he wrote: "We have made a determination for acid number, and we find that the acid number of the extract 2.09 per cent, by gasoline, was 110.8. Using this figure, together with a normal acid number of 160, we estimate that two-thirds of the residue obtained by the extraction would be rosin. It would mean that the wood showed about 1.38 per cent rosin." Mr. Kloss rightly emphasized that "we must appreciate that these results are only approximate and should not be used for calculations where any great importance is attached thereto. Before such figures would be available it would be necessary to make a number of determinations, as you, of course, realize."



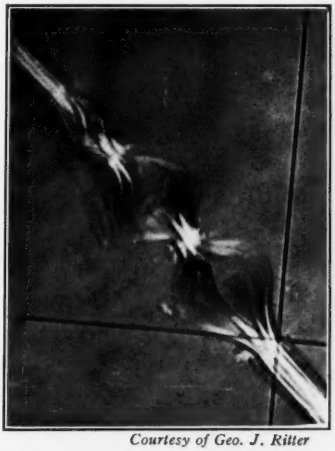
Courtesy of Geo. J. Riller

SEPARATION OF DELIGNIFIED CELL WALL OF ELM INTO FOUR DISTINCT LAYERS BY MEANS OF A 68% SOLUTION OF PHOSPHORIC ACID

I fully agree with Mr. Kloss' words of caution, but these results should stimulate further inquiry into this most remarkable possibility. Confusion has no doubt resulted from the fact that the slash pine is a heavy producer of oleoresin. But the fact that has been completely overlooked is that the great bulk of this material is not physiological resin but has been produced pathologically in the outer layers of the wood after the tree has been wounded in the weekly process of scarification.

I am not a paper chemist and the 1.38 per cent of rosin in the young

slash pine may be entirely too much for utilization in pulp without deresinification, but I do want to suggest the desirability of a group from this great paper and pulp industry sitting around a table with a similar group from the naval stores industry and discussing these matters freely. My confident belief is that rich returns will follow such a coöperative movement. Many matters of mutual interest could be discussed, and I believe the inauguration of valuable research studies would follow.



Courtesy of Geo. J. Ritter

THREE SEPARATED LAYERS OF A DELIGNIFIED ELM FIBER AT CONSTRICTED PLACES AND TRANSVERSE SWELLING OF TWO INNER LAYERS

The Forest Products Laboratory has already done some valuable work on the utilization of Southern pines for light-colored, strong paper, but they are handicapped by inadequate appropriations. The Pine Institute of America has research under way, at the Mellon Institute at Pittsburgh and in southern institutions, whose ultimate result is going to be the widening of the market for naval stores. The cause of resin flow, a fundamental question, is being carefully studied by Dr. Eloise Gerry of the Forest Products Laboratory. I found no record of the length of the fiber from slash pine; from analogy I think it is safe to say it is between 3 and 4 millimeters. Last fall I saw a carload of slash pine cones being shipped to the western part of the southern pine belt for purposes of propagation. That is a source of further income. The Southern states are very favorable in their attitude toward tax relief for reforestation of the cut-over lands. Through the nearby port of Savannah, Georgia, there is quick access to all the eastern markets by steamer shipment, and to the markets of the middle west through the network of railroads proceeding from that territory.

Courtesy of Geo. J. Ritter

SECTION OF OUTSIDE LAYER SHOWING SPIRAL STRIATIONS EXTENDING AROUND FIBER AT RIGHT ANGLES TO FIBER'S AXIS

Need for Fundamental Research

Courtesy of Geo. J. Ritter

A MORE COMPLETE SEPARATION OF CELL-WALL LAYERS INTO MINUTE FIBRILS

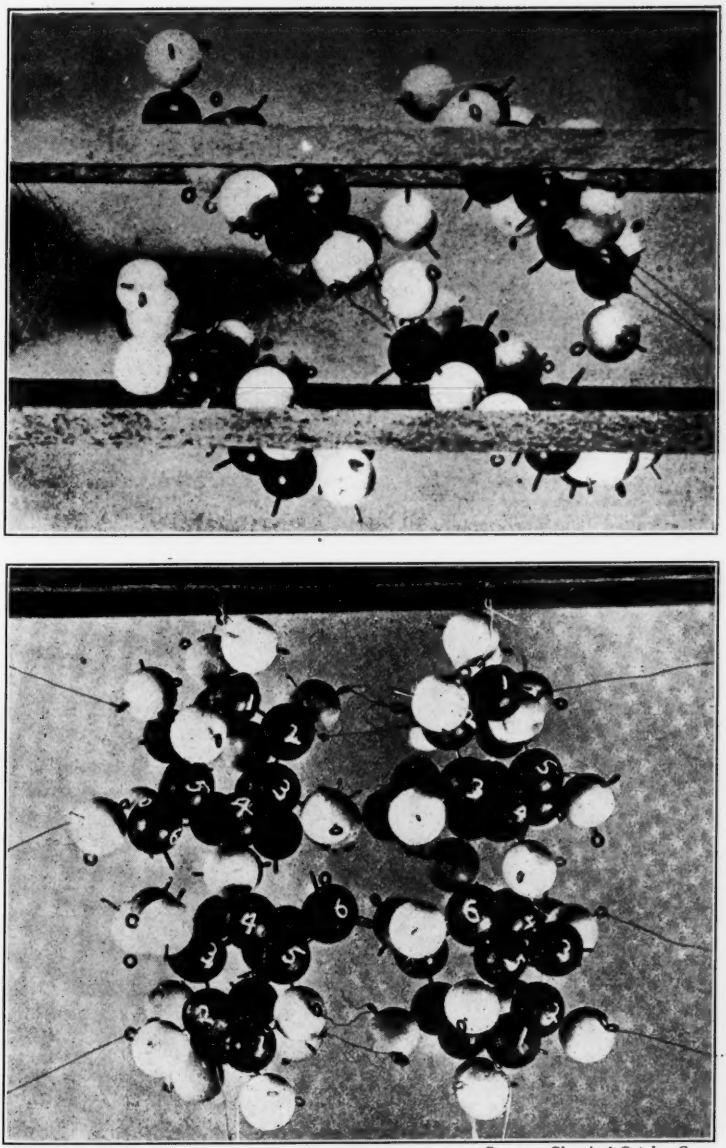
All of these questions are subjects for mutual discussion and study. But there is another need. We must carry on intensive fundamental research on the structure of the cellulose molecule. Valuable work on this subject has been done by Dr. George J. Ritter of the U. S. Forest Products Laboratory, who has perfected a separation of the delignified cell walls of the elm into four distinct layers, and these have been separated into fibrils and then into "fusiform" bodies, using microscopic methods. During a recent visit at the Forest Products Laboratory I asked Dr. Ritter what magnification he was using. He replied "one thousand." Then I talked with Dr. Winslow, Director of the Laboratory, and urged him to send Dr. Ritter to the Rockefeller Foundation in New York, where he could familiarize himself with the work being done in the study of living tissue by Dr. Alexis Carrel, using from 30 thousand to 50 thousand magnification, because when they went from 10 to 30 thousand they got an entirely new conception of what was going on in the living cell. I hope Dr. Ritter is going to be given a chance to follow that up.

In California, Sponsler and Dore are making use of that latest tool of scientific research, x-ray penetration of the material, and find evidence closely conforming to chemical evidence.

The chemical evidence, I regret to say, comes to us from European countries, where research on such a problem receives better financial support. In Germany valuable contributions

Courtesy of Geo. J. Ritter

SHORT SECTIONS OF DELIGNIFIED ELM FIBERS, SHOWING BUNDLE-LIKE RESIDUE OBTAINED WHEN DISSOLVING ACTION OF PHOSPHORIC ACID IS ARRESTED BEFORE OUTER LAYER IS COMPLETELY REMOVED



Courtesy Chemical Catalog Co.

PHOTOGRAPHS OF 3-DIMENSION MODEL REPRESENTING THE STRUCTURE OF RAMIE CELLULOSE

Four of the double C_6 units are shown. Black balls represent C atoms; white balls O atoms. Position of H atoms is indicated by the short pointed wires. The screw eyes represent the probable location of the secondary valence forces. —*Sponsler and Dore.*

are being made by Dr. Kurt Hess and his associates, supported strongly by the industry. Nearby is Professor Herzog, in a special institute, working on fiber chemistry by all of the modern physical methods. At the University of Berlin, Professor Hans Pringsheim's work has the backing of the wood distillation industry. In Scotland, Sir James Irvine is making notable contributions. So, too, in the Scandinavian countries.

In Canada there has recently been dedicated a Pulp and Paper Research Institute, under the direction of Professor Harold Hibbert, supported jointly by the Canadian Paper and Pulp Association, the Canadian Government, and McGill University.

Does it not bring a feeling of chagrin to realize that the greater part of the work in this field has been done in foreign laboratories? Surely the day cannot be far distant when thoughtful men in the cellulose-consuming industries will see to it that America does not lag behind in this rational road to progress. Perhaps they will follow the example of the petroleum industry, which is already reaping rich rewards from its research, supported through fellowships in educational institutions under the coördinated direction of the Central Petroleum Committee of the National Research Council. Whatever form it takes I do not hesitate to predict improvement of established industries and the development of many new uses for cellulose.

I want right here to pay tribute to the Brown Brothers of Berlin, N. H. I happened to go through their plant several years ago when they were first getting out alpha-cellulose. Three-fifths of the rayon last year came from alpha-cellulose. It shows the benefit of constant research and constant seeking out for something a little further ahead than the routine matter we have every day. That is the spirit which must lead in the march of civilization.

After all, industry is prone to be prodigal of its resources. The pulp and paper industry is more thrifty than the lumber industry, which utilizes only one-third of the tree. At first thought the paper and pulp industry is credited with utilizing about two-thirds of the tree, but this is wrong, for of the part which reaches the mills some 30 per cent goes out again with the waste. This is the so-called lignin, a material about which we know practically nothing and which affords abundant material for intensive study. It represents about 30 per cent of the composition of all wood, and if we compare the cellulose of plant and tree to the steel structure of our skyscrapers, lignin represents the brick and mortar. Some 65,000,000 tons of lignin are produced every year in the United States, 40,000,000 tons from our farms, 25,000,000 tons from the forests, and not a thing is being done with it. The Department of Agriculture started a good man, Dr. Max Phillips, to work on this subject, but now I understand they have taken him off to spend most of his time on hack jobs.

In these days of conservation and utilization can we rest content with such conditions? Let me leave as a last thought the words of David Sarnoff, a successful industrialist, who says: "The greatest danger to any industry in the world is self-complacency."

THE MINNEAPOLIS MEETING, SEPTEMBER 9 to 13, 1929

The next national meeting of the American Chemical Society, which is scheduled for the early fall, promises to be one of unusual interest. The Division of Chemical Education will devote four half-day sessions to the reading of papers in the School of Chemistry of the University of Minnesota.

An excellent program, glorious Minnesota weather, and wonderful roads and scenery are individual and collective attractions which, it is hoped, will induce many chemists to include the trip to Minneapolis in their vacation plans.

The railroad associations are expected to grant the usual round trip rates of one fare and a half. "Terminal facilities," at a very low cost, have been promised in University living centers. Free parking and camping sites will also be available.

Particular attention is called to the rules regarding the presentation of papers.

1. Papers by American chemists not members of the society shall not appear on the program unless they be joint papers with society members.
2. Papers already in print shall not be presented except by special invitation.
3. The secretary has been instructed to place on the program no papers *by title*.
4. The completed paper, accompanied by an abstract (in duplicate) of not more than 100 words, must be in the hands of the secretary of the Division before August 3rd. Papers received after this date will be held over, with the consent of the author, for the Atlanta program in the spring of 1930.
5. In general not longer than 20 minutes will be available for each paper, *including* discussion.
6. All papers read before the Division are the property of the A. C. S. unless released by the society's editors.

Authors are requested to file notice of prospective papers with the secretary as soon as possible, indicating whether lantern or moving picture apparatus will be needed, and enclosing an abstract. This procedure will enable the committee to properly correct the program.

Following the plan successfully instituted at the Columbus meeting, manufacturers of chemical apparatus and products, high-school and college laboratories, and other agencies which are interested in chemical education are invited to send exhibits for the Minneapolis meeting. Free exhibition space will be reserved upon request. Exhibitors must assume all costs of transportation and packing, as well as responsibility for breakage or loss.

Attention is called to the *Symposium on Chemical Kinetics* during the second summer session at the University of Minnesota, July 29th to August 31st. The following lecturers will be in residence: PROF. H. S. TAYLOR of Princeton University; PROF. M. POLANYI of the Kaiser Wilhelm Institute of Chemistry; PROF. S. C. LIND of the University of Minnesota.

COÖPERATION OF THE UNIVERSITY WITH INDUSTRY WITH SPECIAL REFERENCE TO PULP AND PAPER*

H. K. BENSON, UNIVERSITY OF WASHINGTON, SEATTLE, WASHINGTON

The dependence of industry upon research is quite generally admitted. According to a recent estimate American industry makes an annual expenditure of $200,000,000 for research in the laboratories of the United States. While a large part of this expenditure is made in the laboratories of the industrial plants themselves, the dependence of the industries upon the research of the higher educational institutions is not to be ignored. Not long ago a speaker discussed the progress of medicine. He pointed out that while improvements in the technic of surgery might be made and modifications of anesthesia were constantly attempted, the profession of medicine was really waiting for chemistry to push out the borders of our knowledge concerning the human body. The nature of the chemical compounds in the body fluids, the mechanism of the reactions within these fluids, the identification of body catalysts and of transferring media still lay in an unknown background. Until chemistry entered into it and laid open this field, the practice of medicine would have to go on as it has in the past by cut-and-try method and the dubious art of experiment and observation. Even in chemical industry the same kind of wistful warning has been sounded. In the public addresses of Dr. M. A. Stine, Chemical Director of the du Pont Company, he gave utterance to the statement that industry has caught up with chemistry and physics and until a new set of facts was accumulated and laid out for inspection industry could not be expected to make its maximum stride. In the quest of new facts and more facts, the du Pont Company has just recently built and equipped a new laboratory for research in the field of pure science and it will pour millions of dollars into making up this deficiency in the output of the pure science research of our colleges and universities. The insistency of this demand is even seen in the very institutions that were created to accelerate the processes of industrial research. The problems studied in the Mellon Institute often seem remote from industrial application and the newly created Battelle Memorial Institute with its large staff of research workers announces that it will largely confine itself to research in the field of pure science.

From the trend of this movement and the anxious hesitancy of our industrial leaders it is evident that the highest type of coöperation between the universities and industry is the promotion of research within the university itself. What the precise nature of that research may be is immaterial as long as the frontier of our knowledge is pushed out.

* Presented at the Pacific Northwest Regional Meeting of the American Chemical Society, Portland, Oregon, April 7, 1928.

It is impossible and also needless to place an evaluation upon a newly discovered fact. In 1861 Pflücker, a German physicist, published his observation that a magnetic field caused an electric arc to deflect itself from a straight to a curved path. Forty years later when Samuel Eyde went to his professor of physics, Theodore Birkeland, at the University of Christiania, to discuss means for increasing the surface of an arc, he was told of the observation made many years before by Pflücker. Thus was born the Birkeland-Eyde method of nitrogen fixation which has been so potent in the foreground of the synthetic nitrogen industry, and which in turn has safeguarded the world's food supply against the exhaustion of the Chilean deposits.

When Faraday for the first time demonstrated in a lecture before the Royal Society the fundamental principle of electromagnetic current some one in the audience said, "All very nice but what use is it?" Faraday replied, "Perhaps some day you can tax it." That was nearly one hundred years ago, and in 1925 one of the largest manufacturers of electrical machinery in the United States paid an income tax of over seven and one-fourth million dollars.

These two citations should be ample to show the dependence of industry upon the production of facts—the contribution of knowledge resulting from research and scientific investigation apart from immediate application to industry. This function of the university cannot wisely be diminished by industry and it must be fostered and encouraged in every way possible by providing a free and untrammeled environment in the university itself.

Today we are especially concerned with the contribution of scientific research to the pulp and paper industry and the question that is uppermost in our minds is the means of contact between this industry and the research that is possible within the university. Before we can find this common ground let us see what interests are common and what problems are of joint interest.

The chemical nature of the reactions in the conversion of wood into paper is often obscured by the maze of intricate, extensive, and delicate mechanical operations which are required. Nevertheless, the pulp mill and the paper mill too are essentially chemical plants. A long list of chemicals is required by the industry considered as a whole. Sulfur, lime, dolomite, soda ash, liquid chlorine, hypochlorites, sulfate of soda, sulfite of aluminum, sodium resinate, glue, sodium silicate, starch, clay, casein, calcium sulfate, barium sulfate, and numerous dyes constitute the list of raw materials which must be assembled. Numerous transformations in the processes add greatly to the list. The industry must deal with sulfur dioxide, bisulfite, sulfurous acid, caustic soda, and sodium sulfide. Often salt is electrolyzed for chlorine and caustic soda, and hydrogen is

available as a by-product. Sometimes tannin is a by-product as is also turpentine.

Even the mechanical processes are surrounded by sets of facts whose fundamental properties are defined in terms which are often not understood.

> The modification of the colloidal properties of the fibers, the distribution of the fibers into a wet sheet or mat, the development of cohesion between the fibers and the breaking of the colloid by heat, are some of the major reactions in the every-day process. Closely related to them are side reactions such as the coating of the fibers with water-resistant materials, the hydrolytic disintegration of the fiber by acids and the effect of electrolytes in the water-suspending medium upon the colloidal nature of the fibers.[1]

These reactions are the subject matter of chemistry and physics and in the domain of these two sciences are to be found the facts that are necessary for their control. Whenever the university adds to a fuller understanding of these fundamental concepts it may be said to be coöperating with the industry to the fullest extent.

There is another aspect, however, that is perhaps not so fully recognized by the university in its scheme of work and that is the technological aspect which requires a special adaptability of technical facts to the industry. It is in this field that the industry itself has made commendable progress, but it is a field to which the university may well contribute more fully in the future than it has done in the past. A brief review of some of the advances will indicate the nature of the work which must be done in the university if it will desire to measure up more fully to its opportunity.

The consumption of steam for the digesters, for drying the paper, for heating the bleach liquor and the wash water has been enormous. Much of it is lost in the relief gases of the digesters, or in the contents of the digesters when blown; in the condensate from the black liquor evaporators; in the stack gases from the boilers and black liquor incinerators; and in the warm air which is passed over the paper machine driers. The introduction of heat interchangers and accumulators offers an inviting opportunity to the technologist for effecting economies in mill operation. The flow of fluids is of especial significance when it is remembered that water is the chief conveyor in the pulp mill. That it is not fully understood is evident from the fact that in some mills as little as 2500 gallons to as high as 40,000 gallons per ton of paper is used. When it is remembered that this water contains fiber, involves the consumption of steam and in many cases of chemicals for water softening, the reduction in water usage will constitute an important factor.

During the past few years marked progress has been made in the field of high-pressure reactions. Recently, the use of such pressures in the

[1] Rue, *Chem. Met. Eng.*, **35**, 15–7 (1928).

disintegration of fibers has been made in the production of masonite pressed board but its application to pulp making still awaits the experimentalist. The introduction of suction filters in dewatering operations, of the countercurrent diffusion system in leaching of black ash and washing of pulp, of sedimentation equipment, of the rod mill as an efficient refiner for knots and screenings and beating engine for pulp and the emulsification of rosin size, testify to the progress made in the technology of pulp and paper making. The problem of drying pulp still causes serious consideration. The colloid character of the fibers is a determinant in such properties as shrinkage, stretch, warping, curling of the edges, and opacity. The factors of humidity and rate of drying are still somewhat vague. The growing tendency of legislation to interfere with the discharge of pulp wastes into streams calls for the introduction of new methods of recovery that are far from satisfactory solution. The economic reburning of lime sludge has eliminated one kind of waste, but the problem of sulfite waste liquor is a serious one in many localities.

To what extent the university curriculum may contribute to the solution of the technological problems enumerated seems at first sight somewhat remote. Perhaps the most obvious plan would be the institution of special courses in pulp and paper making such as have been established in a few institutions in the United States and Canada, or the more common establishment of governmental agencies as the special laboratories at Toronto, Canada, and Madison, Wisconsin. But the need for diversified training in fundamentals rather than in the specific is far more appealing to those in charge of our educational programs. The need for technological training has been distinctly recognized in planning the chemical engineering curricula now offered in some sixty institutions in the United States. In these curricula, in addition to chemistry and physics, emphasis is laid upon mathematics and engineering and more recently there has been developed a course dealing with the unit operations of manufacturing. In this course, use is made of engineering methods as applied to the flow of fluids, flow of heat, grinding, evaporation, drying, distillation, mechanical separation, filtration, humidifying diffusion, adsorption, and extraction. Each operation is surrounded by the facts which are pertinent to it, and by means of data contributed from chemistry, physics, mathematics, the various formulas and computations are utilized for governing and controlling the operations. Essentially, it is a course that correlates the material scattered throughout the whole curriculum. It establishes a broadminded technical judgment that enables the scientific worker to reach into the appropriate field of science for the tools required to adjust and reconstruct a given process or operation in industry. It is possible, for example, to cover the essentials of every operation in the pulp mill without ever once mentioning the word pulp. In providing such training

for industry, the university is engaged in the closest coöperation possible.

Thus far we have endeavored to show the community of interest between industry and the normal functioning of the university. Upon its research and its output of trained men industry may depend for its means to make progress toward greater efficiency and the solution of its problems. There are, however, other devices for making the planes of interest coincide more closely. The faculties of our institutions and the technical executives of industry might well meet often together in the tent of common interest. The problems of the pulp industry might in many cases become the problems of research in the university laboratory. The facilities of the latter are often ideal for carrying on investigations totally unsuited to the plant laboratory. The plant on the other hand affords opportunity for adaptation not possessed by the laboratory. The two together make for conciseness and precision in investigation that add not only to its interest but remove it from the highly academic and theoretical nature that characterizes the research of the university.

At the recent meeting of the Technical Association of the Pulp and Paper Industry were presented a number of papers on the development of a method for determining the weight of a given area of a moving web of material. This is accomplished by the possibility of detecting minute changes in weight and length by measuring the changes in capacitance of a radio condenser whereby a continuous record of all the material passing through the condenser plates is given. Although great advances have been made in the application of radio telegraphy in communication, very few applications to commercial purposes have been made, but through the efforts of an amateur radio enthusiast we now have a means of determining and controlling the moisture in paper drying as well as the weight of the paper being made on a paper machine. By means of this radio apparatus a method is available for the automatic control of steam for the driers. A more uniform sheet is made and less wood pulp is used to make a desirable sheet. It permits the paper manufacturer to reduce the cost of his paper and gives the printer a more desirable product, easier to print, and free from static.

The example quoted is indicative of the application of some of the newer phases of scientific experimentation and by its very remoteness from the field of paper making illustrates the gain that may be expected when the industry closely affiliates itself with those who are constantly moving about in the midst of scientific progress. The ways and means of a closer affiliation between industry and our colleges and universities can perhaps not be specified. One way is that chosen in this meeting today. We have invited the representatives of the industry to meet with us in this discussion and we are also planning to visit the industries. In this mutual intercourse we are taking a step toward the place of communal

interest. Another means here on the Pacific Coast is the organization of a section of the Technical Association of Pulp and Paper Manufacturers and the holding of meetings for the discussion of technical problems in the pulp industry.

Before concluding it may be permissible to assure industry that the universities of the country and of the Pacific Northwest are keenly conscious of the responsibility for the progress of industry. The place of research in the university is continually becoming more prominent. The training of men with a suitable background for industry will be uppermost in our purpose. Beyond that the doors of our colleges and universities will be open in welcome to the representatives of industry for mutual helpfulness and coöperation.

Synthetic Diet for Plants Nears Achievement. Feeding plants on a synthetic chemical diet will be achieved long before human beings are in a position to subsist on concentrated synthetic foods, Dr. W. S. Landis, Vice President of the American Cyanamid Company, indicated in a recent communication to the American Institute.

In fact that day of pure chemicals as plant nutrients has already arrived through the use of concentrated chemical fertilizers. Synthetic nitrogen chemicals, such as cyanamid, urea, and nitrate of lime, are blended with other chemicals, such as ammonium phosphate, potassium phosphate, potassium nitrate and other like combinations that place in the fertilizer nitrogen, phosphate, or potash in a form that plants can assimilate. Plants cannot live on these chemicals alone, as small quantities of manganese, zinc, vanadium, titanium, and many other elements are needed, besides carbon dioxide and water, from which the bulk of plant foods are manufactured by the plants themselves.

"The future fertilizers will be much more concentrated in the three common plant foods than even past history would lead one to suppose," said Dr. Landis. "The older organics of animal or vegetable origin will disappear to still greater extent and will be replaced by newer synthetic salts mostly of inorganic nature. Process limitations existing today will disappear in so far as they eliminate essential plant foods and the science of compounding will be greatly elaborated as we acquire better knowledge of plant requirements and soil deficiencies."—*Science Service*

Three Institutions Share Chemical Research Fund. The first award under the Frasch Foundation, established by the will of Elizabeth Blee Frasch, for research in the field of agricultural chemistry has been made, giving half of the award, $20,000 annually over a period of five years, to the Boyce Thompson Institute for Plant Research in Yonkers, New York; $12,000 annually to the University of Missouri, and to the University of Wisconsin, $8000.

It is proposed that the funds be applied mainly to salaries, the institution obtaining the award to supply the equipment and materials for the investigations. In the case of the Boyce Thompson Institute a large laboratory is being equipped especially for this work and Dr. F. E. Denny will handle the research on effect of stimulative chemicals on plant growth; while Dr. Frank Wilcoxon will conduct the special insecticide and fungicide investigations.

At Wisconsin the fund will be devoted to the biochemistry of microörganisms in connection with fermentation studies already under way, while at Missouri the project is entitled "The Efficiency of the Animal Growth Process at Various Ages and under Various Conditions of Management."—*Science Service*

TRAINING CHEMISTS FOR THE INDUSTRIES

CHARLES A. KRAUS AND SAMUEL T. ARNOLD, BROWN UNIVERSITY, PROVIDENCE, RHODE ISLAND

While there has been much discussion of certain phases of chemical education during the past few years, surprisingly little has been said concerning the subject matter that should be included in the course of study of the prospective chemist. Granted that the instructing staff is capable of presenting various subjects to the student in an interesting and understandable manner, there still remains the broad question as to what particular subjects in chemistry and the allied sciences, as well as in the humanities, constitute a suitable course of training for the student who expects to enter chemistry as a profession.

How, for example, should a student's efforts be distributed between chemistry, physics, mathematics, biology, engineering, English and the foreign languages, economics, psychology, etc.; and where does research come in? Should the undergraduate student receive some training in the methods of research? Should first-year graduate students devote a considerable portion of their time to research or should they, instead, confine their efforts in the main to routine courses, including laboratory work? Certainly, a graduate student cannot be expected to carry on any research work that is worth mentioning if, at the same time, he is to carry on an appreciable amount of routine laboratory work. The demand made on the student's time is constantly increasing. The call is ever for a broader training in science, for greater familiarity with research methods and for a better understanding of the languages and of various allied subjects. With the rapid development of science, necessitating a greater concentration of the student's attention on new fields, where is he to find the time necessary for carrying out this ever-expanding program? And, if he cannot find the time, what is he to drop out of his course? If we continue to teach everything in chemistry that has been taught up to now and add thereto the new material that is fundamental and important, where is the student going to "get off?"

The problem is obviously an intricate one and it is not our purpose to present a solution here. We may say in passing, however, that the obvious thing to do is to organize the subject matter of our curricula with greater care so as to avoid wastage and to adapt the courses of instruction to the needs of students individually. In other words, the course of training for each student should be laid out to meet his particular needs and abilities so that he may accomplish a maximum result with minimum expenditure of time and effort. This procedure should be put into practice as early as possible during the student's undergraduate years and should be continued throughout his later work.

A large majority of our graduates in chemistry find their way into the industry and even those who enter the academic field usually have some industrial contacts, as, indeed, they should if they are to interpret chemistry successfully to their students. Accordingly, it seemed to the writers that some light might be thrown on this problem by consulting with industrialists who come in contact with the human material supplied to the industries by the colleges and universities. The writers took occasion to visit a number of industrial and research laboratories for the purpose of gaining some idea of the industry's views on this matter. Various laboratories were visited and questions relating to the training of chemists were discussed with those in charge. Below are given the general conclusions that may be drawn from these discussions. On the whole, there was a greater unanimity of opinion than might have been anticipated. Owing to special needs of various industries, emphasis was placed on various phases of chemical training and specific defects in our system of training, as commonly practised, were pointed out. On all major questions, there was substantial agreement. The opinions expressed on various points are summarized below.

Analytical Chemistry.—There was general agreement that the fundamentals of analytical chemistry, both quantitative and qualitative analysis, are of primary importance in the training of chemists. Students need not be trained in special methods of analysis but they should be familiar with the various types of instruments employed in modern analytical and research laboratories. In many technical laboratories the new men are started on some kind of analytical work and it is evident that students not well trained in analytical chemistry are handicapped at the outset. This applies particularly to graduates of four-year courses; men who have received the doctorate are more commonly started on research problems. The opinion was quite generally expressed that the quantitative side of chemistry should be stressed throughout the student's course of training.

Organic Chemistry.—There was general agreement that the student should be well trained in the fundamentals of organic chemistry. The importance of organic analysis was emphasized by a number of men who were in close contact with the organic chemical industry. Highly specialized courses in organic chemistry were not favored. The industries prefer to give their chemists any special training that may be essential to their success. Particularly striking was the emphasis placed on physical chemistry, physics, and mathematics as an adjunct to the preparation of an organic chemist.

Industrial Chemistry.—Opinions as to the value of industrial chemistry varied. For the most part, it was thought that industrial chemistry served a useful purpose in giving students an idea of plant organization

and operation. It was suggested that students could gain valuable plant experience by working during the summer.

Engineering.—This subject was not particularly stressed, either by directors of research laboratories or by plant managers. Some engineering training was considered valuable provided that it was along broad lines. Specialized engineering training was distinctly not favored. The tendency was rather to emphasize physics and mathematics, particularly in an under-graduate course. Briefly, engineering training was considered secondary to that in the fundamentals of physical science.

English.—Facility in the use of the English language was stressed on every hand and there was general agreement that the men supplied to the industries by the universities are woefully lacking in this respect. This defect is particularly noticeable in those laboratories in which research workers have to make frequent reports. Seemingly, few of our graduates have the ability to present their results in suitable form either for a technical or a non-technical reader. This condition appears to be quite serious and there can be no doubt that, so far as English is concerned, our system of language instruction is practically a complete failure. Those who have had occasion to read first (or second) drafts of theses presented for graduate degrees will agree with the industrialists on this point.

Foreign Languages.—A reading knowledge of foreign languages, particularly German, was considered essential by those who expressed themselves on this subject.

Mathematics and Physics.—More training in these subjects was uniformly recommended. Those who expressed themselves were usually quite emphatic on this point. The prevailing impression was that our training in this direction is not carried as far as it should be. The importance of thermodynamics was emphasized.

Collateral Subjects.—The opinion was frequently expressed that chemists should have some knowledge of economics, psychology, etc. Public speaking was also mentioned. In other words, anything touching on human relations is of value to the chemist.

The Newer Developments of Chemistry.—No decided sentiment was found in favor of introducing the newer developments of physics and chemistry, such as the modern atomic theory, etc., into the curriculum. It was evident that few of the chemists interviewed had given this problem serious thought. Only in a few instances, where the industries had already come in direct contact with recent theoretical and experimental developments, was a decided and favorable opinion expressed. It was suggested that the ideas underlying the modern atomic theory should be introduced into chemistry at the beginning of the freshman course.

Research for Undergraduates.—No decided opinion was expressed in favor of introducing research problems into the senior year of the under-

graduate course. Research for undergraduates was favored to some extent as a means for interesting the student but seemingly not for the purpose of training the student in research methods.

Research for First-Year Graduate Students.—Practically every one, with whom the question was discussed, favored the plan to have the graduate student undertake some research problem in his first year of graduate work. In general, much emphasis was placed on the students' research training throughout his period of graduate study. However, research should not be carried on at the expense of the students' further training in fundamental subjects underlying chemistry or physical science generally.

Personality.—The importance of personality as a factor determining the students' success in the industries was stressed. The industries require men who fit into the modern type of organization. High character and the ability to mingle readily are essentials. Initiative and enterprise are at times more important than "brilliancy." The personality factor was more strongly stressed by plant managers than by research directors but its importance was pointed out by all.

Methods of Teaching.—While the methods of teaching, as now practised, were not specifically criticized, some research directors thought that the curiosity and interest of the student should be stimulated more generally. The power of independent thought and the spirit of inquiry should be developed. It was suggested that students of the research type might be separated from others and given a broader course of training, particularly along physical lines.

Summary.—To recapitulate, there was general agreement among those who come in close contact with the graduates of our colleges and universities that practically all the fundamental courses in chemistry now given should be substantially retained. It was generally agreed, however, that there is no need for specialized courses in any subject. There was a strong sentiment in favor of broadening and strengthening the training of chemists along mathematical and physical lines but this should not be done at the expense of the fundamental chemical subjects. It was generally conceded that chemists are inadequately trained in the use of the English language. Our graduates, for the most part, have no facility in expressing themselves. A knowledge of the elements of economics, psychology, and similar subjects is very desirable. A reading knowledge of German and, if possible, of French is desirable, even in the case of undergraduate students. Finally, the student's personality, that is, his attitude toward his work, his ability to make contacts with other men, etc., is a primary factor in determining his success in practical life. In brief, in the opinion of chemists who are actively engaged in the industries, students should have all the fundamental work that we now give them

and, if possible, a great deal more along physical and mathematical lines. In addition, the more knowledge they have in the way of languages and cultural subjects, the more valuable they prove in the industries.

Remarks.—In order to meet the requirements of the industries, our students need more thorough training, particularly in collateral subjects. How to arrange to give the students additional work in physics, mathematics, physical chemistry, English, the foreign languages, etc., without diminishing their training along purely chemical lines is a problem that the universities will have to solve. Already the student's time is so completely occupied with required and routine courses that he has all too little time for independent thought. If he should be loaded up with more required work, he would become more of an automaton than he already is.

The only thing that can be done immediately is to redistribute the student's work in so far as this is possible. Much valuable time would be gained if students were properly prepared in English and the foreign languages. There is no reason why students should not enter college with at least two years each of German and French. At the present time they usually present not more than two years of one language. In this connection it may be mentioned that most students entering the graduate school have insufficient preparation in the foreign languages, to say nothing of English. The truth of this statement is witnessed by the fact that in all graduate schools candidates for advanced degrees are required to pass language examinations. A great deal of the student's time is wasted in attempting to acquire a knowledge of the languages at a time when the acquisition of such knowledge is more difficult than it would have been earlier.

By properly laying out the course of study of the undergraduate student in chemistry, adapting it to his individual abilities and interests, it should be possible to give those students, who have facility along physical and mathematical lines, a more thorough foundation in these subjects. The success of this method will depend upon the care with which the individual cases are studied.

Those who have had experience will agree that the adequate preparation of graduate students for practical life in a period of three years is rather an appalling task. The students who come to us have practically no knowledge of research and, in general, only a rather vague and elementary knowledge of the fundamentals of science. It is well-nigh impossible to give these men the training that they require in the time that is available. The remarkable development of the atomic theory, which now has a direct bearing on nearly all phases of chemistry, has introduced a tremendous mass of important material that needs to be added to what has previously been considered as being more or less essential to the student's training. It is becoming increasingly difficult to give the student

an adequate knowledge of chemistry and allied subjects and, at the same time, to provide that measure of leisure which is essential for the development of independent thought.

There is little or nothing that can be dropped out of the student's course of study. Time can be gained only by a more economical use of such time as there is. One obvious thing to do is to utilize the summer months. These could very profitably be devoted to research, thus allowing more time for study and thought during the remainder of the year. In the three years of graduate study now commonly required for the doctorate, the equivalent of one year could be gained for research. For those interested, it may be mentioned that a plan of this type is now in effect at Brown University.

Any one familiar with the state of chemistry 25 or 30 years ago cannot but be struck by the enormous increase in opportunity along chemical lines. Never before has there been so great a demand for competent chemists. At the same time, it is very noticeable that the industries are becoming increasingly discriminating in their selection of men. They insist on a proper combination of ability, training, and personality. One cannot but feel that the opportunities for mediocre students are becoming more and more limited. Our colleges and universities must take account of this fact and undertake not only to train but also to select men who combine those qualities that are essential to success.

One of the more encouraging features of the present investigation has been the whole-hearted interest shown in the subject by every one with whom we came in contact. We cannot mention the names of all those who so kindly contributed of their time and thought. We shall, however, mention some of those who assisted us in making the necessary personal contacts. These include Dr. Whitney of the Research Laboratory of the General Electric Company, Dr. Mees and Dr. Clark of the Eastman Kodak Company, Dr. Carveth of the Roessler & Hasslacher Chemical Company, Dr. Weidlein and Dr. Tillotson of the Mellon Institute, Dr. Edwards and Dr. Faragher of the Aluminum Company of America, and Mr. Holmes and Dr. Tanberg of the du Pont Company. We are particularly indebted to Dr. Carlisle of the Roessler & Hasslacher Chemical Company for making arrangements for us to meet a large company of chemists at Niagara Falls at luncheon where we had an opportunity to listen to a most interesting discussion for several hours. We also are indebted to Mr. Krauss of the du Pont Company for arranging numerous interviews at Wilmington.

Science is the soul of the prosperity of nations and the living source of all progress.
—PASTEUR

BIOPHYSICAL CHEMISTRY. PART I*

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There was a time when chemistry and its sister sciences, physics and biology, followed their separate ways. They are now trespassing on one another's domains, and it is often impossible to say whether a given problem is chemical, physical, or biological. New and vigorous branches of science, like physical chemistry, biophysics and biochemistry, have come into existence. Their vitality is due in a large measure to the transplantation of the methods and principles of one science to another. In the present article we shall follow this lead and combine some of the data of chemistry, physics, and biology. This will enable us to throw some light on the behavior of the colloidal substances of which living tissues are composed, and to obtain perhaps a glimpse of what the future has in store in the way of an explanation of vital phenomena.

Biocolloids

The name colloid (from the Greek, kollodes = glue-like) has been applied to gel-like bodies such as gelatin, soap, rubber and their solutions, and also to dispersions of insoluble materials, like gold in the purple of Cassius. One fact which connects these apparently unrelated types of systems is that they contain particles much larger than ordinary molecules, yet below the limit of microscopic vision (10^{-5}–10^{-7} cm.). Zsigmondy was the first to define colloids in terms of particle size and his definition is still largely used. As a result of this larger size of the ultimate particles, the properties of diffusibility through membranes, osmotic pressures, lowering of freezing point, etc., are not readily observed in colloid systems and were at first entirely overlooked. Graham's original definition of colloids was based upon these negative findings.

Closely connected with the particle size is the large amount of surface per unit mass[1] of dispersed substance, and the surface forces which come into play. It is known that substances in a fine state of division acquire properties not possessed by them when in lump form. Finely dispersed metals possess therapeutic properties which are not discernible in the same materials, either in bulk or in the ionic or molecular form. Colloidal silver, gold, lead, copper, etc., have been successfully used in medicine of recent years. Mercury in a somewhat coarser state of division, as "grey powder" has been in use for a longer period. Other striking ex-

* Based on a series of five lectures delivered at the Second Institute of Chemistry, Northwestern University, in August, 1928.

[1] Ostwald, Wo., "Grundriss der Kolloidchemie," T. Steinkopff, Dresden, **1909**, p. 84.

amples of peculiar behavior connected with the presence of large surface are supplied by "spongy" platinum which causes the spontaneous ignition of coal gas, and by specially prepared metallic oxides which exert catalytic action (quickening of chemical reactions).

We shall presently see that matter at the surface of bodies, and also in the gel state—is endowed with certain properties which distinguish it from other states of matter. Among these properties are:

1. *Adsorption:* greater concentration at surfaces or interfaces.
2. *Orientation:* arrangement of molecules in definite directions or patterns.
3. Extensibility—(stretching).
4. Photosensitivity—easily affected by light.
5. Electrical and chemical responses to mechanical stimuli.
6. Non-stoichiometric relation among constituents: *i. e.*, "combination" not in simple ratio.
7. Curved forms.
8. Periodicity.
9. Catalytic action.

Adsorption and Some of Its Effects

The concentration or adsorption at surfaces or interfaces was among the earliest colloid phenomena investigated. The ideal condition for the adsorption of a substance AB (Figure 1) at an interface between two non-miscible liquids C and D exists when the substance AB contains within its molecule a group or radical which has affinity for the liquid C and another which has greater attraction for the liquid D. For instance, soap in the presence of oil and water will tend to accumulate at the interface with the —COONa group toward the water and the hydrocarbon group toward the oil (Figure 3). In the absence of oil some of the soap goes to the surface of water forming a monomolecular film with the hydrocarbon end toward the outside while the excess is thought (by McBain)[2] to form brush-like micells (Figure 2).

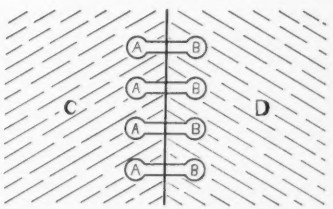

FIGURE 1.—ADSORPTION AND ORIENTATION OF MOLECULES AT THE BOUNDARY OF TWO LIQUIDS

Substances which accumulate at the surface of small particles and prevent their coalescence are known as *protective colloids*.

[2] McBain, J. W., Bogue's "Colloidal Behavior," McGraw-Hill Book Co., New York City, **1924,** Vol. 1, p. 414.

A theory put forward by Finkle, Draper, and Hildebrand[3] sought to explain why sodium and potassium soaps favor the stabilization of emulsions of oil in water, like milk, while the metallic soaps of bi- and trivalent metals like calcium or aluminum cause the formation of a water-in-oil emulsion, like mayonnaise. It was claimed that the relative volume occupied by the groups A and B in the two liquids was the determining factor (Figures 3 and 4) but the actual radius of the atoms involved has been shown to have little to do with the explanation.[4] One may nevertheless assume that if the repulsion between the A-groups of the adsorbed molecules is greater than between the B-groups then the interface will bend toward the latter, and vice versa. Or, otherwise expressed, the sodium salt end has greater affinity for water than the hydrocarbon end has for oil and the interface is concave toward the oil; on the other hand, calcium has less affinity for water than the hydrocarbon has for oil and the water becomes dispersed in the oil (emulsion photos, Figures 5 and 6).

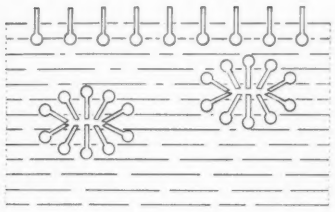

FIGURE 2.—ORIENTATION AT SURFACE AND MICELLS IN A LIQUID (*e. g.*, SOAP IN WATER)

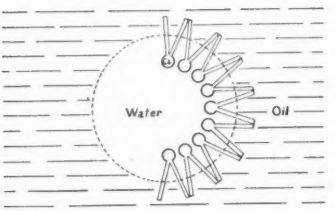

FIGURE 3.—MONOMOLECULAR LAYER OF SODIUM SOAP MOLECULES, FAVORING AN OIL-IN-WATER DISPERSION

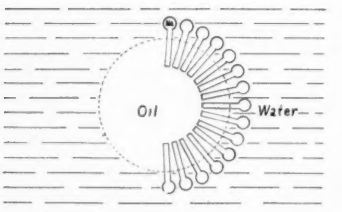

FIGURE 4.—MONOMOLECULAR LAYER OF CALCIUM SOAP FAVORING A WATER-IN-OIL DISPERSION

Clowes[5] explains the variations in the permeability of cell membrane, on the hypothesis that it is a complex emulsion of colloidal substances—the two phases of which are capable of undergoing reversal. When the oil-like lipoids form the external phase the membrane is soluble to fats and fat-soluble substances, while when the proteins form the outer phase the membrane becomes permeable to salts, and water-soluble substances.

Adsorption may be either reversible or irreversible. In the field of physiology, the action of narcotics is explained on the basis of reversible

[3] Finkle, Draper, and Hildebrand, *J. Am. Chem. Soc.*, **45**, 2780 (1923).

[4] Harkins, W. D., and Morgan, J. W., *Proc. Nat. Acad. Sci.*, **11**, 631 (1925).

[5] Clowes, G. H. A., *J. Biol. Chem.*, **29**, viii (1917).

adsorption.[6] Narcotic substances are preferentially adsorbed by the matter which composes the nerves and produce temporary anesthesia. Some are adsorbed mainly at synapses (nerve joints) and cause sleep. After a time, however, they diffuse into the rest of the tissues, or are chemically changed, and the nervous system returns to its normal conditions.

FIGURE 5.—PHOTOMICROGRAPH OF OIL-IN-WATER EMULSION (80× DIAM.)

The formation of concentrated films or "cell walls" at the surface of protein solutions is, on the other hand, frequently an irreversible phenomenon. Irreversible surface adsorption also takes place when essence of rennet is shaken. The enzyme present therein collects around the air bubbles and becomes concentrated in the froth while the liquid loses its milk-curdling property.[7] Adsorption also plays an important part in the action of antitoxins and many other biological processes.[8]

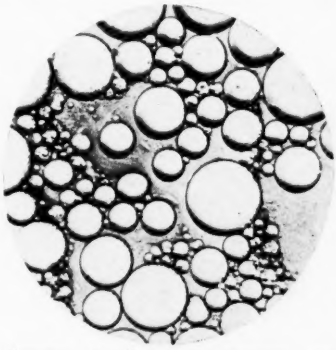

FIGURE 6.—PHOTOMICROGRAPH OF WATER-IN-OIL EMULSION (80× DIAM.)

Orientation—Thixotropy

In discussing adsorption, it has already been pointed out that the molecules at surfaces or interfaces tend to arrange themselves in a definite manner.[9] This molecular orientation links colloid dispersions, and emulsions, to gels; elastic gels (*e. g.*, fruit-jello) are commonly supposed to consist of a rigid framework of oriented molecules with a large amount of enmeshed liquid. Figure 7 shows a particle A of a dispersion or emulsion floating in the surrounding liquid, B. There are two phases, a phase being a region in which the substance is uniform throughout. The transition between A and B is, however, not

[6] McClendon, J. F., "Physical Chemistry of Vital Phenomena," Princeton, **1917,** 134; Spiegel, L., "Chemical Constitution and Physiological Action," D. Van Nostrand Co., New York City, **1915.**

[7] Cofman—Nicoresti, J., *Pharm. J.*, **117,** 351 (1926).

[8] Seifriz, Wm., Alexander's "Colloid Chemistry," Chemical Catalog Co., New York City, **1928,** Vol. II, p. 415.

[9] Langmuir, I., *J. Am. Chem. Soc.*, **39,** 1879 (1917); Harkins, W. D., *et al.*, *J. Am. Chem. Soc.*, **39,** 541 (1917).

sudden. There exists a more or less extensive *region of transition AB* as shown in Figure 7. This surface or *interfacial region* is not strictly another phase because its composition is not uniform. It possesses, apart from orientation, several remarkable properties and may be said, as already mentioned, to be responsible for the behavior of colloid systems.

FIGURE 7.—TWO PHASES *A* AND *B*, AND AN INTERFACIAL REGION *AB*

Diagram of a particle of emulsion or dispersion.

In gels and, I believe, in many living colloids, one or both of the true phases may be absent, as shown in Figures 8 and 9. In the latter case all that remains is the *region* of oriented molecules. The ideal colloid may be said, figuratively, to consist of surface only and to contain no mass in bulk—if by surface one understands the "region of molecular orientation."

The forces which hold together the molecules and molecular aggregates that form the framework of the gel are sometimes very weak. In some instances it is sufficient to shake the container in order to liquefy the gel. On allowing to stand, the system again becomes rigid, sometimes within a few seconds. This rapid sol-gel transformation has been named "Thixotropy."[10] The living protoplasm also behaves at times as a rigid body, while at other times it appears to be a viscous liquid. Its consistency seems best explainable in terms of molecular orientation.

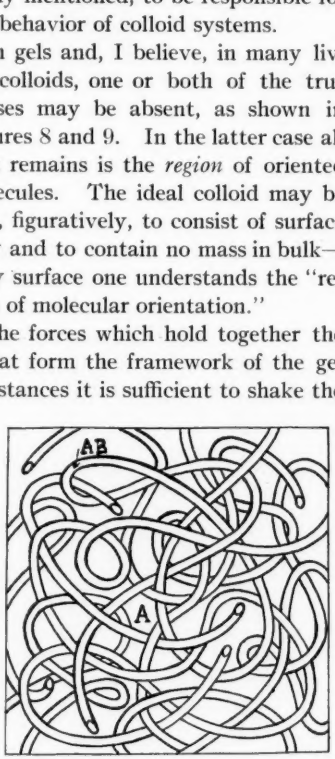

FIGURE 8.—ONE PHASE *A* AND AN "INTERFACIAL" (MICELLAR) REGION *AB*

Diagrammatic structure of gel liable to syneresis.

Extensibility—Photosensitivity—Surface Conductance

The Multiply-Shared Electron.—The arrangement of molecules in a gel has certain resemblances to the arrangement of atoms or groups in a crystal. Elastic gels possess certain optical properties which have long ago been associated with crystalline structure, and also x-ray diffraction patterns (especially when stretched). On the other hand, they strongly differ from true crystals on account of their extensibility and, as we shall see later, curved forms.

[10] Freundlich, J., and A. Rosenthal, *Koll. Z.*, **37**, 129 (1925).

In extensible bodies, like rubber or the skin of animals, the forces between molecules seem to extend considerably further than in crystalline or brittle substances. In the light of modern theories of atomic structure the forces which hold matter together are assumed to be of electrical origin. *It seems convenient to imagine* that in the case of extensible substances the shared electrons revolve in larger orbits so that the atoms can move further apart and still remain within one another's sphere of attraction (Figure 11). These electrons may serve as a bond not solely between two atoms—as the present orthodox electrons do—but may move around several atoms or molecules, within the micell or in the region of molecular orientation.

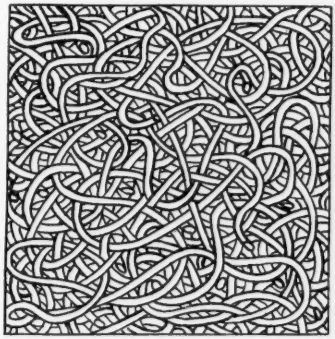

FIGURE 9.—INTERFACIAL (MICELLAR) REGION ONLY (ELASTIC GEL)

If one postulates such loose electrons traveling around many atoms and serving as a bond between them, one is naturally led to inquire about the radius of the orbit and the number of revolutions per second. The former might be derived from the true extensibility of a substance—if we knew how far apart the molecules or particles are when the limit of elastic stretching is reached. Unfortunately, such data are difficult to obtain.

The frequency of rotation of the hypothetical multiply-shared electrons could be correlated with the photochemical effect. It is known, for instance, that light, especially in the ultra-violet region, has the property of reducing the viscosity of colloid solutions, presumably by breaking down the micells.[11]

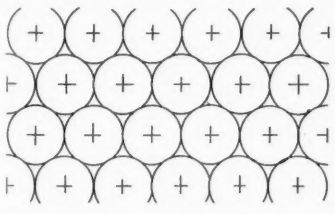

FIGURE 10.—SCHEMATIC DIAGRAM OF ORBIT OF ELECTRONS MOVING AROUND SINGLE POSITIVE NUCLEI (BRITTLE SUBSTANCES)

The phenomenon of electrical surface conductivity which is apparently of an electronic nature[12] may form eventually another link in the chain of phenomena explainable in terms of the multiply-shared electron.

It is not in any way implied that the above tentative hypothesis corre-

[11] Samec, M., *Kolloidchem. Beihefte*, **23**, 377 (1927); Bacon and Wilson, U. S. patent, 1,397,915.

[12] Briggs, D. R., "Colloid Symposium Monograph," Chemical Catalog Co., New York City, **1928**, Vol. VI, p. 45.

sponds to the actual state of affairs in a colloid particle. It would be foolish to do so at a time when the concept of the electron itself seems to be dissolving into waves.[13] The hypothesis of the multiply-shared electron is put forward as an example of an attempt to bring together apparently unrelated properties like extensibility, light sensitivity, and surface conductivity, concerning which the theories of classical chemistry give little hope of solution.

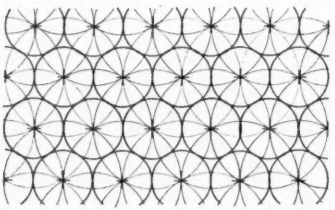

FIGURE 11.—DIAGRAM OF ORBITS OF ELECTRONS MOVING AROUND SEVERAL NUCLEI (EXTENSIBLE SUBSTANCES)

The most important aspect of the multiply-shared electron is that it does away with the necessity for stoichiometric (simple-ratio) proportions in colloid compounds.

The Rule of Inconstant Proportions

A glance at Table I shows the relation of colloids (gels and dispersions) to other kinds of matter. It will be noticed that their place is somewhere between strictly chemical compounds, like water or salt, and the easily separable, coarse, physical mixtures.

The viewpoint of classical chemistry is characterized by a certain rigidity of outlook. Its foundation is the law of constant proportions; it attaches most importance to fixed properties like boiling and melting point and to crystalline form. But the physical chemist, and especially the biologist, has to work with substances of constantly varying composition and properties. He must supplement the classical chemists' point of view, and adopt new methods and ideas.

The law of constant proportions was, and still is, a useful concept so long as one restricts oneself to crystals or liquids of constant boiling point, but it becomes useless, or even misleading, when applied to gel-like elastic bodies or amorphous precipitates.

As an example—suppose equivalent amounts of tri-sodium phosphate and lead acetate are dissolved in water and mixed together. Under the guidance of the law of constant proportions one expects the resulting precipitate to consist of lead phosphate, $Pb_3(PO_4)_2$. What actually happens is that the solution of lead acetate, which is slightly acid to begin with, becomes even more acid after the addition of the strongly alkaline phosphate, and the composition of the precipitated lead phosphate varies continuously with the change in acidity of the solution.

The above example is of interest because it helps to explain why salts of divalent ions (*e. g.*, calcium lactate) though often themselves alkaline, are

[13] Van Vleck, J. H., *Chem. Rev.*, **5**, 467 (1928).

TABLE I*

	Homogeneous Chemical compounds		Physico-chemical compounds			Heterogeneous Physical mixtures		
	Chemical compounds	Dissociable compounds	Hydrates and alloys	Hydrous oxides; oxy-salts	Colloid compounds (elastic gels)	Solutions	Fine dispersions or emulsions	Coarse dispersions or phys. mixts.
Crystalline form	+	+						
	+	+	+					
Constant composition	+	+	+	(+)				
	+	+						
Unlike their constituents (discontinuity in properties)	+	+	+	(+)				
	+	+						
Elastic, but not extensible	+	+	+	(+)				
Energy change accompanying formation	+	+	+	+	+	+	(+)	
Composition varies with external conditions		(+)	(+)	+	+	+	+	
					+	+	+	
Properties depend on P, V, T variables			+	+	+	+		
				+	+			
Curved outline extensibility				+	+			
					+			
Constituents can be separated by gravitation								+
						(+)	+	+

* Two crosses indicate that the property referred to in the vertical column is very marked in the system; one cross shows a lesser preponderance while in the systems marked (+) the particular property is of secondary importance.

employed in order to decrease the alkalinity of the blood. Calcium is precipitated by the phosphate and carbonate present in the blood, in the same way as lead is; the precipitate carries down with it some of the hydroxide either "adsorbed" or in the form of a basic salt, leaving the blood more acid. Whether the adsorbed substances are to be considered chemically or physically bound is a matter of definition or individual preference.

Electrical Behavior

If the combination among atoms does not take place in simple proportions one may expect the resulting particles to be electrically charged, due to excess or deficiency of electrons. The colloid particles or micells are, as a rule, electrically charged and will move in an electric field (cataphoresis). Abramson has recently suggested that the movement of the white

blood corpuscles toward a point of injury is due to this phenomenon. White blood corpuscles are known to be charged negatively while the injured tissue becomes acid (electropositive).*

If the electrically charged colloid material forms a fixed framework and cannot move under the influence of the electric field, then the liquid contained in its interstices is set in motion. This fact is made use of in the dehydration of peat through the passage of an electric current (electro-endosmose).

In living cells water is known to flow at times against the osmotic pressure from a more concentrated to a less concentrated solution. This "negative osmosis" may be due to electrical osmose. W. H. Hardy remarks: "I find it difficult to believe that water-holding electrolytes can be drawn through even living matter without there being a potential gradient."[15]

The importance of electrical phenomena in physiology is being increasingly appreciated. "Every functional change in a tissue tends to induce a difference in electrical potential," states Steel.[16] "One can hardly touch a gel without causing a difference in electrical potential," remarks Michaud.[17] A. V. Hill writes, "The electrical potentials in the animal are extremely important both theoretically and practically; practically because they enable us to follow events in the body, *e. g.*, the heart beat, in a manner possible by no other means; theoretically, because all transmission of messages to a distance as *e. g.*, in the nervous system is accomplished by a something—the so-called "impulse"—which is probably nothing but a self-propagating wave working upon the potential difference maintained during life at a surface or membrane. It is probable that we think, and feel, and see, and carry our responses by utilizing the surface phenomena at membranes which are similar in many ways to glass bulbs or oil films."[18]

The present writer has shown elsewhere[19] that whereas a compression wave in a gas produces alternate heating and cooling effects, a similar disturbance in a gel or surface film leads to the propagation of an electrical

* "If there is a difference of potential in the membrane of the capillary wall of 1 millivolt (with the assumption that the negative stream is toward the point of injury) and if the thickness of the wall is 0.5μ the drop in potential is 20 volts/cm. This e. m. f. is of sufficient order of magnitude..... to bring a white cell cataphoretically to the point of injury within the time required for this process to occur."[14]

[14] Abramson, H. A., Colloid Symposium Monograph, Chemical Catalog Co., New York City, **1928,** Vol. VI, p. 128.

[15] Hardy, W. H., *ibid.*, p. 7.

[16] Steel, M., "Physical Chemistry and Biophysics," John Wiley & Sons, New York City, **1928,** p. 359.

[17] Michaud, F., *J. Chim. Phys.*, **21,** 386 (1924).

[18] Hill, A. V., *Manchester Lit. Phil. Soc. Proc.*, **68,** 13 (1923–24).

[19] Cofman, V., *Chem. Rev.*, **4,** 32 (1927).

potential wave. Erlanger and co-workers[20] have obtained lately more detailed information on the nature of the nerve impulse and shown it to be an "electrical wave." One may even go further and attempt to calculate the velocity with which "thoughts" are transmitted along nerves, from a simple formula similar to that used in the determination of the velocity of sound. The order of magnitude obtained is the same as that experimentally observed (about 50 m/sec.). Certain disturbing factors like the influence of the diameter of the "axon" (nerve fibril) affect the propagation of the nerve stimuli.

[20] Erlanger, Gasser, and Bishop, *Am. J. Physiol.*, **62,** 496 (1922); **70,** 624 (1924).

Sulfur and Hydrogen Hold Cell Life Secret. Sulfhydryl, which is made of one sulfur atom and one atom of hydrogen, is the stuff that makes possible the growth of plants and animals by the division of their cells. Since life cannot continue, nor new organisms arise without cell division, this atom pair may fairly be said to be the key compound to life itself.

At the recent meeting in Philadelphia of the American Philosophical Society, Dr. Frederick S. Hammett explained the steps in his experimentation that have led to this important conclusion. The first hint came from the claim that lead compounds retarded the growth of cancer cells. Since a cancer is only a mass of ordinary cells gone mad about dividing, it would appear that anything that stopped their abnormal career must be something that removed from them whatever gave them the impulse to divide.

Dr. Hammett grew plant roots in solutions of lead compounds, and found that though the cells could increase in size their rate of division was markedly reduced. In the region of most rapid growth lead precipitates appeared, which proved to be compounds of lead with the sulfhydryl group. In roots permitted to grow normally, abundant sulfhydryl was found associated with the most actively dividing cells.

A further step in the evidence was obtained when sulfhydryl-containing compounds extracted from actively growing roots were applied to the tips of other roots. Under proper chemical conditions, these compounds caused acceleration of growth. Finally, synthetic compounds containing the same pair of atoms were similarly used and produced similar results, both in root tips and in the division rate of single-celled water animalcules.—*Science Service*

Winter Sunlight Lacks Shorter Ultra-Violet Waves. Winter sunlight is not only less intense than that of summer, but contains less of the sun-burning ultra-violet waves, Dr. Arthur D. Riddle of the Hegeman Memorial Research Laboratory announced recently to the American Physical Society.

Sun-burn and the other biological effects of ultra-violet rays are produced by a certain band of wave-lengths, not longer than 1/78,000 inch and not shorter than 1/86,000 inch approximately. As the length of the shortest waves in sunlight is some place between these figures, Dr. Riddle made measurements of the limit at different times of the year, both on clear and cloudy days.

His results show that June sunlight, both in clear and cloudy weather, contains shorter waves than even clear December weather. In June, both on clear and cloudy days, waves as short as 1/84,300 inch were present. On a clear December day, the shortest were 1/82,300 inch, while on a dull day no waves shorter than 1/81,800 inch were detected.—*Science Service*

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Pioneers in the Laboratory Teaching of Chemistry[1,2]

TENNEY L. DAVIS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

> A high value is set upon the educational effect of laboratory practice, in the belief that such practice trains the senses to observe with accuracy and the judgment to rely with confidence on the proof of actual experiment.

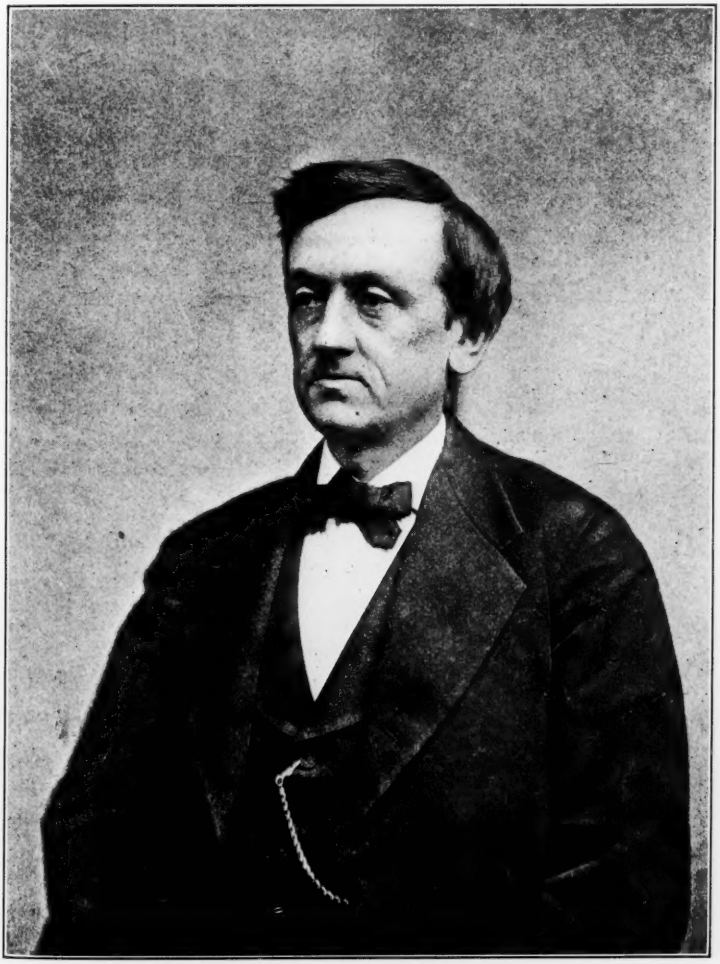
Laboratory courses for students of chemistry are of surprisingly recent date. So also is the equipment of our work, the research and abstract journals, the comprehensive books of reference, and apparatus such as the Bunsen burner and the water pump without which we would find it difficult to proceed. The first regular laboratory instruction in chemistry for undergraduates of Harvard College was given in 1858, six years before the *Bulletin* of the French Chemical Society commenced publication and ten before the *Berichte* made its first appearance. The determined efforts of the young professor, Josiah Parsons Cooke, Jr., had introduced chemistry into the curriculum of a university strongly devoted to the classics. During a period of less than a decade he had developed courses for students of the first, second, third, and fourth years, had planned a chemical laboratory, and had raised money for the construction of Boylston Hall. When the Massachusetts Institute of Technology opened in 1865, President William Barton Rogers, himself a geologist, the son of a chemist and the brother of a chemist, sought for professors to develop laboratory courses in chemistry and selected two men who had attended Cooke's first classes and had acted as assistants in his courses. Both had later studied in Germany under men who were masters of manipulation.

In February, 1865, the Institute opened its preliminary course and held its first classes in a building at 16 Summer Street, Boston, about opposite the present location of C. F. Hovey and Co. There were fifteen students and six professors. Francis H. Storer had charge of chemistry. When the fall term opened in October the number of the faculty had been increased to ten. There were two chemists; Storer was Professor of General and Industrial Chemistry and Charles W. Eliot, Professor of Analytical Chemistry and Metallurgy. During the academic year 1865–66 the Institute's classes, beginning with those of the department of chemistry, were gradually transferred to the new Rogers building on Boylston Street. Storer and Eliot had had the duty of planning the laboratories. They

[1] Presented before the Division of the History of Chemistry at the 76th Meeting of the American Chemical Society, Swampscott, Massachusetts, September 10–13, 1928.

[2] The portraits of Eliot and Storer are reproduced through the courtesy of Dr. Lyman C. Newell from originals in his collection.

were now under the necessity of developing new courses and of preparing textbooks adapted to the new method of laboratory instruction. In its



FRANCIS H. STORER AS HE APPEARED WHEN PROFESSOR AT THE BUSSEY INSTITUTION

larger quarters the chemistry department grew rapidly. In 1868 it occupied "five ample laboratories, a chemical lecture-room, and a recitation room, besides rooms for apparatus, balances and storage."

Francis Humphreys Storer (1832–1914) was the son of David Humphreys Storer, M.D., a distinguished member of a remarkable group of pioneering Massachusetts naturalists of the second quarter of the nineteenth century. He grew up in an atmosphere of scientific research and publication, and was familiar with the scientific work of his father and of his father's contemporaries. His own strong tendency toward scientific studies brought it about that his education did not follow the course usually prescribed for the sons of successful professional men of Boston. He did not go to Harvard, but to the new Lawrence Scientific School, where he spent the year 1850–51. For the next two years he was by choice assistant to Professor Cooke of Harvard, and then at the age of twenty-one he accepted an appointment as chemist to the United States North Pacific Exploring Expedition, and spent a year at sea and in various Pacific ports. At commencement, 1855, he received on examination the Harvard degree of Bachelor of Science, and immediately thereafter went to Europe where he studied under Stöckhardt, Bunsen, and Boussingault. On his return from Europe in 1857, he opened a laboratory in Boston for chemical analysis and general consulting, and maintained it with industry and success until 1865.

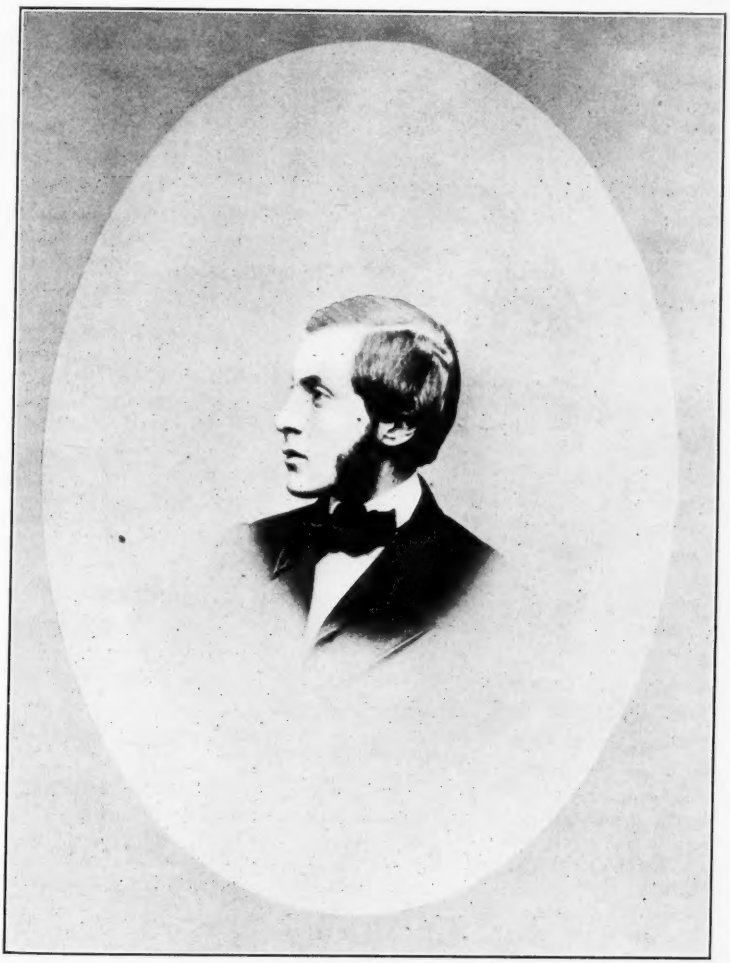
Charles W. Eliot (1834–1926) entered Harvard College in September, 1849. On November 24th of that year Josiah Parsons Cooke, Jr., was appointed tutor, and Eliot became a member of his first class in chemistry. Instruction was limited at first to lectures and recitations, but soon a few lecture demonstrations were added—"Mr. Tutor Cooke providing at his own charge the consumable materials necessary in performing chemical experiments." Convinced of the necessity of experimentation by the individual student, Cooke quietly possessed himself of a room, about 20 by 25 feet in size, in the corner of the basement of University Hall, and, without gas or running water, fitted out a chemical laboratory. At a meeting held in 1894 in commemoration of Cooke, Eliot said:

> I was the first student whom he admitted to the little laboratory in the basement of University Hall, and Professor Frank H. Storer and I were his first assistants, both at the Cambridge laboratory and at the laboratory in the Medical School. I therefore have a vivid recollection of the humbleness of the beginnings of both the chemical and mineralogical departments; of the elementary quality of the instruction given; and of the great disadvantages under which all the instruction was given, without any possibility of offering laboratory practice to the students, except as a favor which could be granted only to very few.

From the middle of his freshman year until the end of his senior year Eliot enjoyed opportunities for the study of chemistry and of mineralogy which were open to no other undergraduate, for he had access to Cooke's private laboratory and to the mineral cabinet of which Cooke had charge.

Eliot continued at Harvard and was awarded the A.M. degree in 1856.

In that year he gave the first half of the course of lectures in chemistry at the Harvard Medical School. In February, 1858, being Tutor in Mathe-



CHARLES W. ELIOT AS HE APPEARED WHEN PROFESSOR AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

matics, he was promoted to Assistant Professor of Mathematics and Chemistry—the grade of assistant professor being then created for the first time in the university—"to give such instruction in the department of

chemistry as may be agreed upon in the distribution of studies by the Faculty." In 1858–59 the first laboratory instruction in chemistry open to Harvard undergraduates was given in Boylston Hall. Although his work was chiefly in mathematics, Eliot had the opportunity to teach small elective classes in chemistry and mineralogy in the new building. In January, 1861, the Harvard Corporation voted "that the duties of Mr. Charles W. Eliot be limited to the chemical department, and that he be designated accordingly." He was given charge of the chemical laboratory of the Lawrence Scientific School. At about this time Eliot and Storer published in the *Proceedings of the American Academy of Arts and Sciences* several original papers in the field of analytical chemistry. Eliot remained at the Lawrence Scientific School until 1863, at which time his five-year appointment as assistant professor expired and he severed his connection with Harvard University.

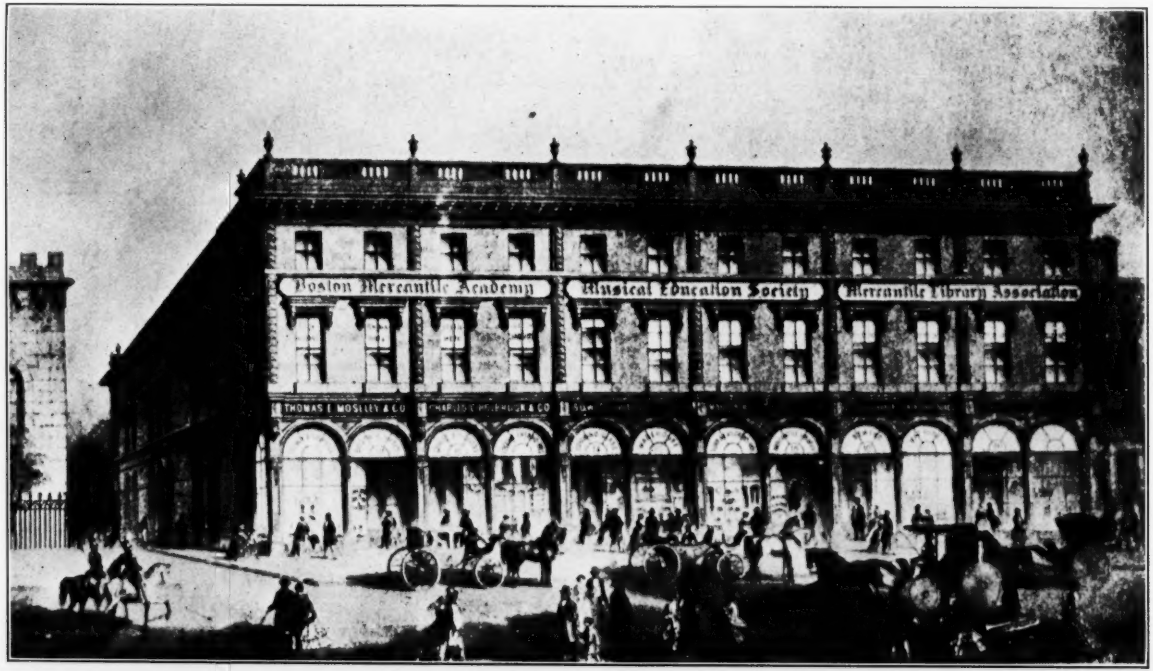
Eliot later wrote:

> In the early summer I decided to stick to the profession of education, and the better to prepare myself for it I resolved to spend two years in Europe, studying educational institutions and pursuing my studies in chemistry and technology. Accordingly, I . . . spent the following two years in England, France, and Germany, making long stays in London, Paris, and Marburg, and traveling moderately during the summers. I thus obtained considerable knowledge of university administration in different countries of Europe, of the organization of technical schools, and of the prevailing methods of teaching chemistry and physics.

In April, 1865, Eliot was offered the position of superintendent of the Merrimac Mills at Lowell, Massachusetts, at a salary of $5000, but declined the offer. In July, while he was in Vienna, he received a letter from President Rogers, written at a time when the preliminary course at the Massachusetts Institute of Technology was drawing to a close. A portion of Dr. Rogers' letter follows:

> My great anxiety now is to make up a good faculty of instruction, and I want you to be one of the number. What say you to taking charge of the laboratory, with such other chemical matters as you and Storer might arrange between you? We shall need at the beginning two chemical professors, one having general chemistry, including lectures on some of the chemical arts, and the other laboratory instruction in its various branches, including metallurgy.
>
> . . . I feel safe in promising you for the first year a salary of $2000.
>
> . . . Hearing some time ago of the large offer made you at Lowell, I feared that you might be tempted to give up science as a profession. It was with no small satisfaction that I learned, a few days since, your determination to hold to your scientific pursuits. I believe that you will never regret that decision.

Eliot accepted the position and found himself again working by the side of his friend and fellow-student, Francis Storer.



THE MERCANTILE LIBRARY BUILDING, 16 SUMMER STREET, BOSTON
In this building the Massachusetts Institute of Technology held its first classes.

In the fall of 1865 these two young professors began work on the Institute's first classes in some hired rooms on Summer Street, but were soon called on to plan and equip the chemical laboratories in the Institute's new building on Boylston Street. These laboratories were planned for teaching chemistry to all students, young or old, beginners or adepts, by the laboratory method. In these convenient and spacious laboratories Professors Storer and Eliot were soon experimenting not only on the students of the Institute but also on classes of teachers, both men and women, employed in schools in and about Boston.[3]

The Institute's first catalog, 1865–66, announces for the first year two courses in the elements of inorganic chemistry, the first on the non-metallic elements, the second on the metals.

In both these courses, the principles of chemical nomenclature and classification, and the more striking facts in the history of the elements and the present state of chemical theory, will be dwelt upon at such length as is consistent with the general elementary character of the lectures; but special attention will always be given to the description of those substances and processes which are of importance in common life or in the useful arts. Practical instruction in chemical manipulations will also be given in the laboratory to every student. This series of lessons will include practice in the construction and use of apparatus for preparing and experimenting with the common gases, acids, bases, salts, etc., which have been described in the lectures.

The catalog also announces a course in qualitative analysis for the second year, and courses in industrial chemistry, including mineralogy and metallurgy for the third and fourth years.

A high value is set upon the educational effect of laboratory practice, in the belief that such practice trains the senses to observe with accuracy, and the judgment to rely with confidence on the proof of actual experiment.

The first catalog also announces courses at the Lowell Institute:

. . . . open to students of either sex, free of charge—A Course of Eighteen Lectures on the Chemistry of the Non-Metallic Elements, by Prof. Storer, on Mondays and Fridays, at $7\frac{1}{2}$ P.M.—A Course of Eighteen Lectures on the Chemistry of the Metals, by Prof. Eliot—Beginning when Prof. Storer's course closes.

In the following year, 1866–67, the two professors gave at the Lowell Institute a course of "Thirty Practical Lessons in Chemical Manipulations."

The second catalog indicates an expansion of the chemistry courses. Cyrus M. Warren had been appointed professor of organic chemistry and gave a course of lectures in that subject which followed the qualitative analysis of the second year. In the third year, quantitative analysis was given, lectures on industrial chemistry, and descriptive and determinative mineralogy; in the fourth year, more quantitative analysis, the preparation of chemical products, and special researches. In describing the

[3] Eliot, "Biographical Account of Storer," *Proc. Amer. Acad. Arts Sci.*, **54**, 415 (1919).

First and Second Editions, 1867 and 1868

first year chemistry this catalog says—In his laboratory work, the student will use a text-book, in which all needed directions to secure safety and success in performing the experiments are minutely given." This was the famous textbook of Eliot and Storer, "A Manual of Inorganic Chem-

istry Arranged to Facilitate the Experimental Demonstration of the Facts and Principles of the Science."

Eliot and Storer's textbook was the first of its kind to be published in the English language, or indeed in any language. Some parts of it were written by Storer and some by Eliot. After the manuscript had been put in type, the authors used the proof sheets in their classes for a year in the Institute laboratories and in this way discovered certain errors and defects and were able to make improvements in the revised edition. It is related that each of the authors maintained that the other's name ought to appear first on the title page. Discussion availed nothing, and it was agreed that a toss of a coin should decide the matter. The coin was tossed. Storer picked it up and announced that Eliot's name was to stand first. Eliot suggested that Storer had not looked at the coin, but Storer refused to admit the allegation—and the book came to be known as Eliot and Storer's. Neither name stands above the other on the title page; they are printed on the same line, Eliot's first. On the back of the binding of the first edition, the initials, E and S, are combined in a monogram in such manner that it is impossible to know which letter ought to be read first. On that of the revised edition, the names of Eliot and Storer are printed in full, but crossed so that neither appears before the other.

The first edition, "Printed for the Authors, Boston, 1867," was entered according to Act of Congress, in the year 1866, by F. H. Storer and C. W. Eliot, in the Clerk's Office of the District Court of the District of Massachusetts, but has a preface which is inscribed "Boston, June, 1867." It has x + 602 + xl pages. The preface commences:

> In preparing this manual, it has been the authors' object to facilitate the teaching of chemistry by the experimental and inductive method. The book will enable the careful student to acquaint himself with the main facts and principles of chemistry, through the attentive use of his own perceptive faculties, by a process not unlike that by which these facts and principles were first established. The authors believe that the study of a science of observation ought to develop and discipline the observing faculties, and that such a study fails of its true end if it becomes a mere exercise of the memory.

The authors state that their book, like all elementary textbooks, is a compilation, and that it contains little which is original "except its arrangement and method, in part, and its general tone." A valuable appendix is devoted to chemical apparatus and manipulation.

The second edition, inscribed like the first to Prof. Josiah P. Cooke, "In token of gratitude and friendship," was published in New York by Ivison, Phinney, Blakeman, and Co., 1868,[4] and comprises vi + 605 + lix pages. It contains a thirty-fifth chapter, lacking in the earlier edition,

[4] The press work was done in London by Taylor and Francis.

which is devoted to a discussion of atomic weights and of the classification of the elements. This chapter closes, and brings the text to a close, as follows.

> In the midst of the doubts and discussions which today envelope chemical theories, the student will do well to remember that all these questions lie without the sphere of fact. They do not affect the actual composition or properties of a single element or compound; they are questions of interpretation, classification, and definition. The existence of atoms is itself an hypothesis, and not a probable one; all speculations based on this hypothesis, all names which have grown up with it, all ideas which would be dead without it, should be accepted by the student provisionally and cautiously, as being matter for belief but not for knowledge. All dogmatic assertion upon such points is to be regarded with distrust...
>
> Theories, however, are of great importance to the progress of the science and to the clear ordering of the ground already won. It is, on this account, very much to be wished that the great attention now devoted to the discussion of the best methods of representing symbolically the constitution of chemical substances and the changes to which they are subject, may result in the elaboration of a system good enough to command general acceptance.

[Proof Sheets.]

A COMPENDIOUS MANUAL

OF

QUALITATIVE CHEMICAL ANALYSIS.

BY

CHARLES W. ELIOT, | FRANK H. STORER,

PROFESSORS OF CHEMISTRY IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

BOSTON:
PRINTED FOR THE AUTHORS.
1868.

Eliot and Storer's textbook went through many editions. "An Elementary Manual of Chemistry, abridged from Eliot and Storer's Manual, with the coöperation of the authors, by Wm. Ripley Nichols, Professor of General Chemistry in the Massachusetts Institute of Technology," is at hand. It consists of xi + 289 + lxiii pages, and was published in New York, by Ivison, Blakeman, Taylor, and Company, 1875. It devotes about seventy pages to organic chemistry. On the back of the binding the names of Eliot and Storer are printed on the same line, superimposed upon one another, the letters of STORER sloping forward and those of ELIOT sloping backward.

Eliot and Storer's "Compendious Manual of Qualitative Chemical Analysis" was first used, in the proof sheets, with the second-year class at the Institute in the fall of 1868. The proof sheets constituted a pam-

phlet of iv + 102 + 37 + vi pages, issued in a flexible black cloth binding, stamped on the front with the words, "Qualitative Analysis," and with the same E-S monogram as the back of the first edition of the "Manual of Inorganic Chemistry." It was revised several times and appeared in many editions. "The Compendious Manual," etc., of Eliot and Storer "as revised by W. R. Nichols, nineteenth edition, newly revised by W. B. Lindsay, Professor of General and Analytical Chemistry in Dickinson College, and F. H. Storer, Professor of Agricultural Chemistry in Harvard University," was published in 1899 by D. Van Nostrand Company, New York.

Eliot taught analytical chemistry and metallurgy for four years at the Institute, until July 1, 1869, when he resigned to become President of Harvard University. He gave up chemistry. His work as an educator belongs to the history of the nation. One of the first subjects to which he gave his attention in his new position was the immediate establishment of the Bussey Institution, for which large funds had been accumulating for several years. Plans were made and carried out for the construction of the laboratories, lecture rooms, library, etc. Storer was offered the professorship of agricultural chemistry in 1870. He accepted, and resigned from the Massachusetts Institute of Technology. In June, 1871, he married Catherine Atkins Eliot, a sister of President Eliot, and the family occupied a house near the main building of the Bussey Institution. In the same year he was made Dean, and continued in that office, while retaining his professorship, until his retirement in 1907.

During his long career as a chemist, Storer contributed numerous scientific papers to the publications of learned societies and to the *Bulletin of the Bussey Institution*, the most important dealing with fertilizers, fodders, foods, wood, and other agricultural chemical subjects. While a consulting chemist in Boston, he published "First Outlines of a Dictionary of Solubilities of Chemical Substances," Sever and Francis, Cambridge, 1864—the first dictionary of solubilities in English and probably the first in any language. Storer's "Cyclopaedia of Quantitative Chemical Analysis" was published by Sever, Francis & Co., Boston and Cambridge, in two parts dated, respectively, 1870 and 1873. The preface states that Storer's object in compiling the work was

> not only to provide the student and working chemist with a comprehensive dictionary of quantitative processes, but to call the attention of the chemical fraternity to the question of the possibility of presenting this branch of the chemical art in a more serviceable and manageable form than has been customary hitherto. The experiment is certainly worth the trying whether a definite system of classifying substances in alphabetical order, and of referring each and every process to the fundamental fact or *principle* upon which it depends, will not greatly facilitate both the study and the practice of analysis.

Concerning the two books—the Dictionary and the Cyclopaedia—Eliot wrote

> Both these were works that could be carried on incidentally and without consecutive attention, in hours which other persons might have considered leisure hours. Professor Storer had no leisure. He relied for the preservation of his mental freshness and his bodily health on change of work, and a persistent habit of omnivorous reading.

Storer's best known publication is probably his "Agriculture in Some of Its Relations with Chemistry," 2 vols., New York, Charles Scribner's Sons, 1887. It was the fruit of his lectures for sixteen years. A demand for the work necessitated the rapid publication of new editions. A seventh edition, "revised and enlarged," appeared in three volumes in 1897.

Eliot attained his greatest distinction as President of Harvard University, Storer his for his work in agricultural chemistry. In their work together they produced textbooks which were standard for several decades and they pioneered with great success in the use of laboratory methods for the teaching of chemistry. If we consider the dates, their work seems recent. If we consider the progress of modern chemistry, it seems early. It is to Robert Hallowell Richards, a member of the first class to graduate from the Massachusetts Institute of Technology, a member of the first classes of Eliot and Storer, that we are indebted for the Richards pump. And many things have developed in chemistry since Richards' pumps were first installed in our laboratories.

Medical Reports on Aluminum Ware. For many years past the public has been interested in cooking vessels made of aluminum. Special interest therefore attaches to the last of the British Aluminum Co.'s pamphlets, entitled, "The Lancet Reports on Aluminum Ware." This consists of two reports published in *The Lancet*, the well-known British medical organ, on investigations carried out under its auspices on the use of aluminum ware for cooking and similar purposes. The first of these was published on January 4, 1913, and the second as recently as December 15, 1928.

The conclusion reached in the former was that aluminum did not communicate poisonous properties to food in the processes of cooking. In order to render assurance doubly sure, the second investigation was made, since, as *The Lancet* points out, statements have been made from time to time that "traces of aluminum in foodstuffs are harmful, and the astounding allegation has been made that cancer may be attributable to food prepared in aluminum vessels." The view put forward as a result of the second investigation is as follows: "Although the published data on the toxicity of aluminum are very meager, the general consensus of opinion appears to be that small quantities are without effect on the living organism. It would appear that aluminum vessels, if of suitable purity, are perfectly safe for cooking purposes, and even if small quantities are conveyed to the water or food, these are without influence on the health of the individual." This authoritative declaration should completely reassure even the most nervous.—*Chem. Age* (*Mo. Metallurgical Section*), **20,** 21 (Mch. 2, 1929).

AND NOW THE MECHANICAL COLOR ANALYZER

GUY BARTLETT, GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

The determination of color may not be strictly a problem for the general chemist, but it is of much importance to dye and textile chemists. The accurate determination of a color previously has been a long and tedious process, requiring hours of work, the making of hundreds of readings, and often the solving of numerous mathematical problems. Now all of this work can be done more accurately, and in less than a minute, by a machine—again the mechanical chemist has entered a new field.[1]

The new apparatus, a recording spectrophotometer, was developed by Professor Arthur C. Hardy of the department of physics at Massachusetts Institute of Technology and on the staff of the research laboratory of the General Electric Company at Schenectady. He described it in November at the annual convention of the Optical Society of America, held at Washington.

With the new instrument it becomes possible to duplicate any color exactly, at any place and at any time. For instance, should a fashion dictator in Paris develop a new color, it would be possible to send a photoradiogram of the spectrophotometric analysis to New York immediately. In that city it could be duplicated by dye experts, even though these men would not be able to see an actual sample of the original color until later.

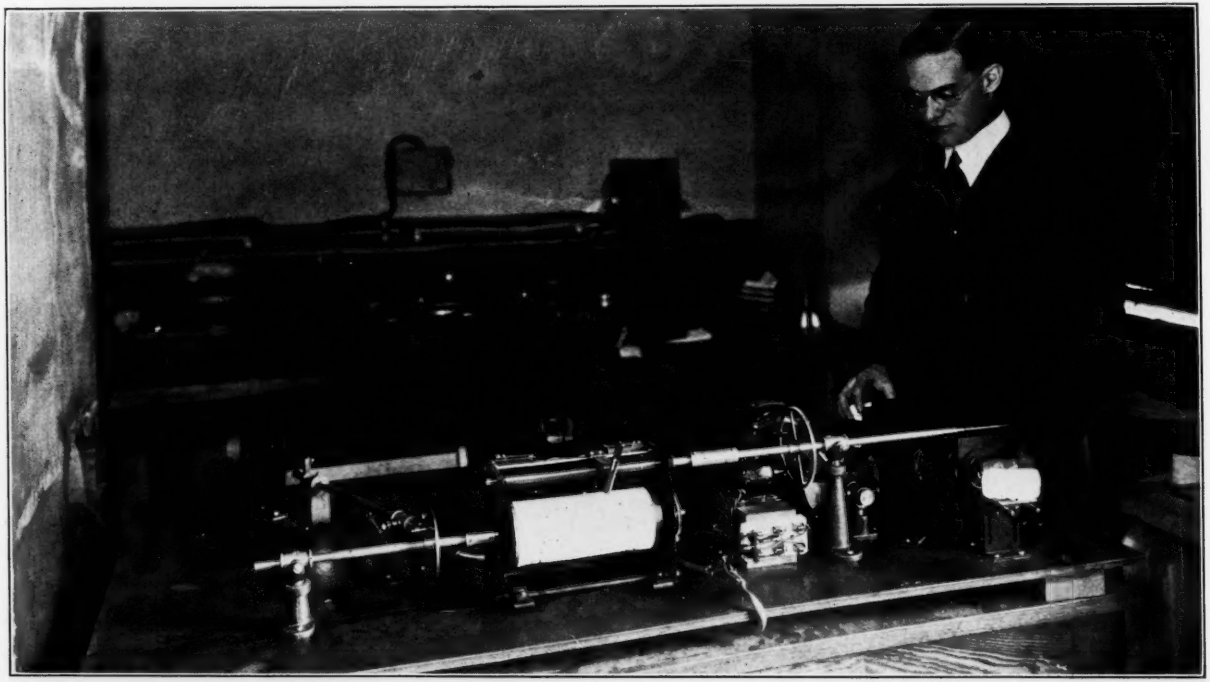
Human judgment, one of the most troublesome elements in the usual methods of color analysis, is entirely eliminated by this device which automatically, rapidly, and precisely measures and records the color and wavelengths of any substance.

Construction of the Instrument

Just as ordinary white light, or sunlight, is broken up into a rainbow of colors if passed through a triangular prism, so is colored light broken up by the prism into bands of different wave-lengths and colors, with some colors more prominent than others. A pure color would have a minimum number of lines, but most of the colors as we know them are far from pure—they are mixtures of various wave-lengths. And that is the reason why some colors which seem to be alike in sunlight differ so much from each other when viewed by artificial light. The prism will show that a sample of a certain green dye contains a little of every color, a decided proportion of red, and a maximum of bluish green, green, and yellowish green.

One of the interesting exhibits in connection with this spectrophotometer is a card containing samples of three pieces of black cloth. All look alike in the daytime, and it might seem that there would be no real

[1] Two other mechanical chemists were described in THIS JOURNAL, **5**, 43–9 (Jan., 1928).



PROFESSOR ARTHUR C. HARDY OF MASSACHUSETTS INSTITUTE OF TECHNOLOGY, AND ON STAFF OF GENERAL ELECTRIC COMPANY RESEARCH LABORATORY, WITH THE NEW RECORDING SPECTROPHOTOMETER

reason for using Dye No. 1, costing more than twice as much as either of the others. Under artificial lights, however, there is a decided difference. Specimen No. 1 remains black, No. 2 becomes greenish, and No. 3 assumes a rusty tinge. Analysis shows that No. 1 is a true black, No. 2 has too much green in its curve, and that No. 3 has the same fault in the red region.

The new color analyzer, a combination of a powerful optical system and electrical devices, automatically analyzes the spectrum of colors and makes a chart of the analysis. A specimen, the color of which is to be analyzed, is placed in a holder and illuminated by a special ribbon-filament incandescent lamp. Magnesium carbonate, the standard of whiteness, is similarly adjusted on the opposite side of the lamp. The light

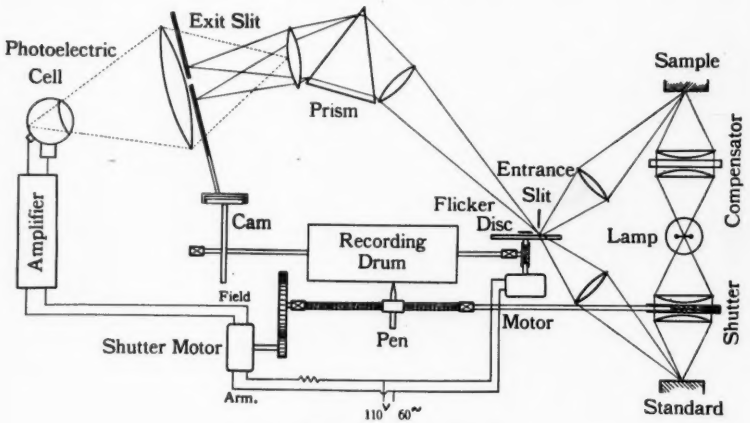


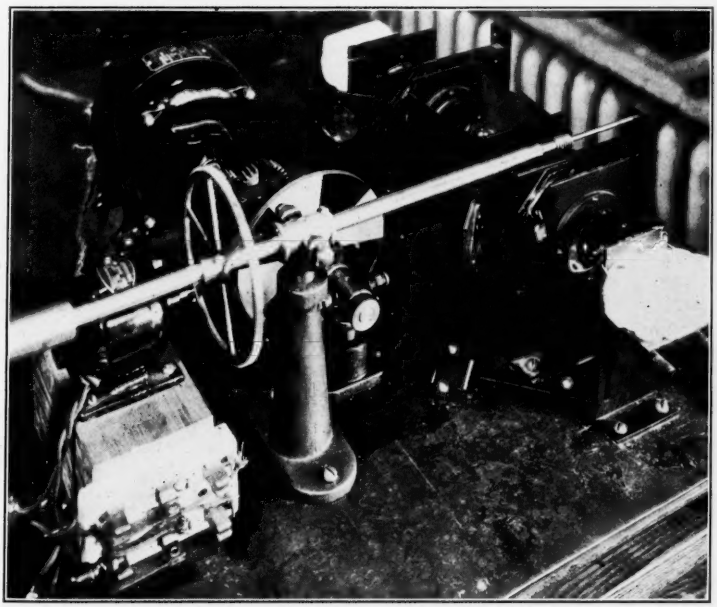
DIAGRAM OF SPECTROPHOTOMETER

from the lamp falls perpendicularly on both the specimen and the magnesium carbonate standard, and enters the slit of an ordinary spectrograph system after reflection from both.

Immediately in front of the slit is a rotating disk with alternate transparent and silvered segments, so located that light from the standard enters the slit when a transparent segment is in the beam, and light from the specimen when a silvered segment is in the beam. The light is dispersed by the spectrograph system, and the proper wave-length band selected by a second slit. Monochromatic, or single wave-length, light is then received by the photoelectric cell in back of the second slit. This light, as received by the cell, pulsates when different amounts of light in that region of the spectrum are reflected by the sample and the standard. This pulsating light is changed by the photoelectric cell

to a pulsating electric current, which is then amplified 10,000,000,000 times and employed to run a small motor. This motor actuates a shutter in the beam between the light source and the standard, automatically adjusting the shutter to that point at which the pulsations in the current cease. This position is independent of the characteristics of the photo-electric cell.

The reflecting power of the specimen is then recorded on a rotating drum by a pen which is attached to the mechanism controlling the shutter



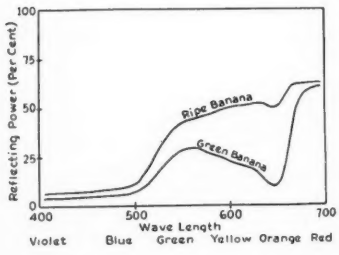
A VIEW OF PART OF THE LABORATORY MODEL OF THE RECORDING SPECTRO-PHOTOMETER, SHOWING THE COLOR SPECIMEN, THE MAGNESIUM CARBONATE STANDARD, THE LIGHT SOURCE, AND THE ANALYZING DISK

just mentioned. A second motor simultaneously rotates the drum and drives the slit across the spectrum, thus giving a complete color analysis in a time which has been reduced recently to less than a minute. In other words, no longer time is now required for a color analysis than for the measurement of some of the simplest of physical properties.

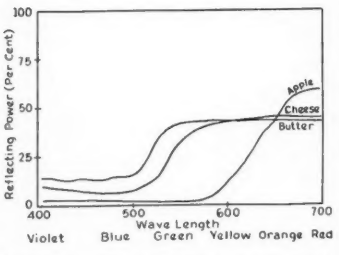
Previous Methods of Analysis

Previous methods for determining colors have been of two types, the color analyzer and the colorimeter. Of these, the colorimeter is the sim-

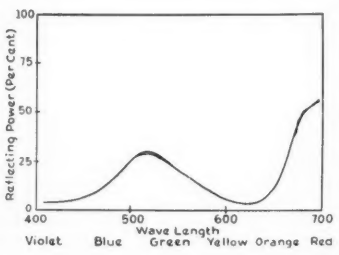
REPRESENTATIVE COLOR ANALYSES MADE WITH RECORDING SPECTROPHOTOMETER



Analyses of ripe and green bananas, showing decided increase in the yellow and orange of the ripe banana.



Typical curves of an apple, cheese, and butter.



A test of the reproducibility of the instrument. Two curves, practically superimposed, of a specimen of green silk.

pler to use. The observer looks through an eyepiece at a divided field, one half of which receives illumination from the specimen under analysis, and the other half of which receives its light from a color that can be controlled at will by the operator, usually by the use of color filters.

Physiologically, the eye is affected in three ways by a color—depending on red, yellow, and blue sensations—and three determinations are therefore needed in matching colors. This method depends considerably upon the personal equation of the operator, and much information is still lacking after the analysis has been made. While the instrument will show when the color of the specimen does not match the standard, and can therefore be used for control work, it does not indicate in what respect the specimen varies.

The color analyzer, on the other hand, produces a record similar to that produced by Professor Hardy's instrument, but with the handicaps of being difficult to adjust, requiring the making of many readings, depending on the sensitivity of the operator's eye, and requiring considerable time for a complete analysis.

Four settings of the analyzer are required for each wave-length studied, and at least 50 points throughout the visible spectrum must be analyzed before the curve is completed. The four readings for each point are averaged, and the curve of the fifty points then plotted. Two operators can, in a speed test, complete an analysis by this method in 20 minutes; but fatigue of the operator's eyes makes it

impossible to complete more than a few analyses in one day. This type of color analyzer therefore is unsuited for routine control work.

Fields of Application

In whatever branch of industry the color of a product is a factor, the new recording spectrophotometer will be of service. In the textile industry, of course, accurate measurement of color is of utmost importance, especially when considering those delicate shades which so easily deceive the eye.

Inks, paints, dyes, paper, lacquer, soap, lard, flour, butter, oleomargarine, cheese, sugar, sirup, chocolate, glass, automobile finishes, tile, brick, roofing materials, carpets, rope, hardware, leather, cement, linoleum, cosmetics—but why continue the list indefinitely—all have their color problems.

In the sale of cottonseed oil the price is affected decidedly by slight differences of color. An amber hue is demanded by buyers at the New York Produce Exchange. If the oil is slightly red—even though the difference in color is hardly noticeable—its price must be less. Lubricating oils are similarly graded on a color basis.

Even when color is not of prime importance, manufacturers usually try to keep it uniform. Fruit canners catering to an exacting clientele endeavor to maintain a standard of colors, since peaches from one can may be placed in the same dish with peaches from another can.

But it is in the field of cataloging dyes that the device will probably find one of its most important fields of application. Having a complete set of curves showing the properties of standard dyes and colors, it becomes possible to obtain new colors with predetermined characteristics by properly mixing the dyes already available.

The elapsed time since Professor Hardy's instrument was developed has not been sufficient to have permitted the testing of its applicability to all of the industries in which it is expected to be of service; but a sufficient number of tests have been made to indicate that the problem of rapid and accurate color analyses has been solved.

Changed Length of Day Speeds Russian Cotton. Shorter days mean quicker growth for cotton plants in the Tashkent region of Russian Turkestan, according to a report submitted by the late Prof. Saitzoff, noted Russian plant scientist, a short time before his recent death.

If the exposure of young cotton plants to daylight was artificially shortened, they branched out sooner and bore their crop at an earlier date, Prof. Saitzoff stated. The ordinarily slow-growing perennial varieties could be induced to grow fast enough to mature their bolls in the climate of Tashkent, where under natural conditions they yield no harvest.—*Science Service*

TRAINING IN CHEMISTRY TO MEET THE NEEDS OF THE PRESENT AGRICULTURAL SITUATION*

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In the final analysis, one of the fundamental causes of the present unsatisfactory condition of agriculture is the lack of proper adjustment between supply and demand. Unfortunately, this adjustment is much more difficult of attainment with the products of agriculture than with those of other industries. There is no other business of national importance which labors under so many handicaps as agriculture, and in consequence there is no other business which requires more intelligence on the part of both the farmer himself and those who are interested in his welfare. The manufacturer, with the comparatively short time required to put his raw materials through his factory processes, is in a position to adjust his production to changing market demands and thus exercise some measure of control over cost and selling price of his commodities. On the farm, where the productive processes of growing crops and animals is greatly prolonged, the farmer is confronted with the uncertain hazards of weather, insect pests, plant and animal diseases, market fluctuations, and other conditions that are quite beyond his control. He is at the mercy of economic conditions which he is unable to foresee at the time of planting, and is not in the position to exercise any appreciable control of production to meet the fluctuating demands of the market, or to adjust his costs to the price which his products will bring when they reach the market. He seeds his winter wheat in the fall to be harvested nine months later. If engaged in livestock farming, he is planting crops in the spring to be harvested and fed to stock the following winter, and may be compelled to repeat the process for several years, with certain classes of livestock, before he can place his product on the market and receive a monetary return. With him the time element is a very serious and limiting factor. On the other hand, with manufacturing, adjustments can be made to changing conditions, as they arise, and raw materials can be resold or diverted into other channels. With agriculture, when once the crop is planted, there can be no adjustment and the farmer must continue with what he has begun even though he proceed under the certain realization of impending financial loss. Because of these handicaps of farming the linking of agriculture with industry under wise coöperative management has become an imperative necessity. We need to have a clear picture of what can be done under intelligent pooling of individual interests. Should not the agricultural chemist, by widening the field of his work, place himself in position to give aid in developing a new and a more satisfactory situation for agriculture by giving a new vision to its

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leaders, of the possibilities of diverting surplus products into new channels and of utilization of farm residues in industrial enterprises?

The fluctuating supplies of agricultural products from year to year constitute an exceedingly serious problem. Often a high production will actually yield smaller financial returns than a short crop, as the following examples will show:

> In 1924 the yield of corn was 2,309,414,000 bushels, valued at the farm at $2,266,771,000. In 1925 this crop yielded 2,916,961,000 bushels which was valued at the farm at $1,966,766,000. Thus the smaller crop of 1924 was worth $300,000,000 more than the larger crop of 1925. The potato crop of 1926 was 354,328,000 bushels, valued at the farm at $501,017,000, while the potato crop of 1927 aggregated 402,149,000 bushels with a value of $387,870,000 or $113,147,000 less than the smaller crop of 1926. In 1926 the production of sweet potatoes was 83,703,000 bushels, the value of which was $78,956,000, while the 1927 crop aggregated 93,928,000 bushels, valued at $77,520,000 or $1,436,000 less for a crop 10,000,000 bushels larger. The 1926 cotton crop aggregated 17,977,000 bales valued at $982,736,000, while the 1927 crop was 12,789,000 bales valued at $1,253,599,000 or $270,863,000 more money value for 5,188,000 less bales in 1927.
>
> The fluctuation in the fruit crop is often wider still. The yield of apples for the whole United States for 1926 was 246,524,000 bushels while the following year it was one-half of this amount or 123,455,000 bushels. The yield of peaches in 1926 was 69,865,000 bushels while that for 1927 was 45,463,000 bushels.

Under present conditions, we may expect agricultural history to repeat itself in this respect again and again, with all the disastrous consequences of extremely unstable values for farm products.

The industrial utilization of agricultural surpluses and residues as a means of promoting closer affiliation between farming and manufacturing has been suggested as a remedy. This suggestion has received consideration from time to time for more than a century, but apparently, in many instances at least, the problem has not been satisfactorily met by our agricultural chemists, neither has it been given serious study in the classroom. At random the other day I picked up a rather delightful little textbook by Herbert Ingle entitled, "Elementary Agricultural Chemistry," published in London, 1926, and I find that he gives this definition for agricultural chemistry:

> Agricultural Chemistry concerns itself with the chemical composition of the food of plants and animals and with the chemical changes involved in the processes of life. It has thus to deal with the composition of soil, air and water, of the bodies of plants and animals, of manures and other materials, and with the chemical changes which these substances undergo.

By this definition, agricultural chemistry is primarily the chemistry of production.

Joseph S. Chamberlain in "Chemistry in Agriculture" (1926), makes this statement:

These three, then, the soil, plants, and animals, form nature's great triad through which a continuous cycle of chemical change is going on.

The farmer is nature's agent in promoting the unbroken continuity of this cycle by cultivating the soil for the purpose of growing plants to serve as food for animals and for man. The art which he practices we call agriculture, and that part of the general science of chemistry that has to do with the knowledge and the explanation of the chemical reactions involved in this bio-chemical cycle we may term, in its broadest significance, agricultural chemistry.

Here again we have agricultural chemistry defined broadly in the terms of production. However, with a wider outlook on the part of the farmer and the consequent developments which are taking place, agricultural leaders are recognizing that it is important that the farmer, whenever it is possible or desirable, should be in the position to follow his product through to the ultimate consumer. This attitude of our agricultural leaders may have a significant bearing upon the type of chemistry which will be needed to cope with the agricultural situation in the future. The manufacture of hides into leather, corn into starch and glucose, straw into paper or decomposition products, and numerous agricultural materials into industrial products, constitutes a line of commercial activities with which the farmer should concern himself.

In the case of corn, a farm crop of major importance, the greater portion is used at present for feeding livestock. Corn also plays an important part as a human food. It is also manufactured into corn oil, cornstarch, and corn sugar. Again the starch is being used commercially in the manufacture of butanol, acetone, methanol, etc., which widens considerably the market for corn.

Unfortunately, the farmer's contention that he receives little consideration in these matters when they are left in the hands of others and that he is receiving too small a share of the value of the finished product of which he is usually one of the largest consumers, in many instances, seems to be well founded, hence we can reasonably expect a more widespread interest on the part of the farmer in determining what actually happens to the material which goes from his hands into the channels of commerce. As his knowledge becomes wider, coöperative effort of agriculture and industry may be more fruitful of results. Modern chemistry has developed methods by which many of the present by-products of the farm may be converted into useful articles of commerce.

America has always been criticized by foreign nations because of the extravagant wastage of its agricultural raw materials. This criticism is one that applies to all new countries, imperfect or improper utilization of natural resources being a consequence of the lack of specialized industries which exists in all sparsely settled countries. In certain cases the improper exploitation of agricultural resources is due to the demands of the very foreign nations that have accused us of wastage and extravagance.

In American colonial times, timber, for which there was no market, must needs be sacrificed (which wanton waste was deeply deplored by following generations) that the necessities of life might be assured. Since there was a market for potash in European countries, it was quite natural that in the process of burning off the timber for clearing the land for agricultural purposes, the ashes should be leached to obtain this very valuable ingredient which in turn could be exchanged for commodities which European countries could supply. From an agricultural point of view, the manufacture of potash from wood ashes, which continued to be an important chemical industry for a period of about two centuries, constitutes one of the greatest economic crimes in the history of the nation. The importance of potash to agriculture at that time, however, was unknown and was not appreciated until the exportation had come practically to an end. This great loss to agriculture upon the Atlantic seaboard in America, which has been assigned as one of the contributing causes of the decline of agriculture in the older states along the coast, was of tremendous advantage to the countries of Europe and especially to England as it enabled their industries to withstand a critical period of potash deficiency. Although the potash industry was agricultural in character, it was conducted by farmers to their own detriment. Later, pitch and tar were produced to satisfy the growing demand, and a thriving industry was built upon these two commodities. Potash and naval stores were thus established as among America's earliest chemical industries.

The production of charcoal for use in the reduction of iron ore for America's infant iron industry and the production of charcoal for use in the manufacture of gunpowder and of pyroligneous acid, which in the form of its iron salt was used as a mordant in dyeing of cloth, were further steps in the utilization of wood which might also be mentioned. Much later in our history, the insistent demand for cheap paper to satisfy the hungry maw of the printing press caused us to turn to the forest for adequate and cheap supplies of raw material and again the woodsman's axe was swung and is still swinging in the interests of another wasteful industry. The treatment of the wood is not so drastic but only the cellulose fraction is used, while the potash and all the rest is spewed out to pollute our streams and is lost to us forever. The magnitude of this industry is so great that it may prove to be a much greater economic crime from a national standpoint than both the other industries mentioned put together. We are no more wasteful, however, in this matter than are other nations of the world.

We are now outgrowing this period of youthful indiscretion and negligence, and the United States can point today to a more highly developed utilization of its raw materials than can any other nation, with a consequent widening of the market for agricultural products, but we are still far from the goal.

The possibilities in this field should be impressed upon our younger agricultural leaders through the proper presentation by our teachers of chemistry. It is important that thought be directed not alone to production but also to possible uses along much broader lines than in the past.

The organization of farmers into large coöperative groups which will operate their own industries and market their own products has been repeatedly proposed and has received very wide support among agricultural leaders. The mortality of such organizations, however, has been exceedingly high due to certain inherent difficulties which at times seem almost insurmountable. Where intelligent and careful management under proper conditions have been obtained, success has generally followed such coöperative effort. The California Fruit Growers' Association, which is not only grading, packing, and marketing the fruit crops but has also established by-product factories, is an outstanding example. The fruits of success from organization seem to be so satisfactory that certain agencies devote considerable attention to encouraging such coöperative enterprises among farmers.

In contrast to this, we can point to industries, depending upon agricultural products, which have entered the agricultural field for the purpose of obtaining adequate and dependable supplies of raw material. A large manufacturer of sweet chocolate operates both dairy farms and sugar plantations to supply his factories with milk and sugar. Large rubber companies have acquired considerable acreages of land to produce supplies of cotton for fabric used in the manufacture of automobile tires and own extensive rubber plantations to insure satisfactory supplies of raw rubber. Sugar refineries in the United States have acquired sugar plantations to insure themselves adequate supplies of raw sugar. A large manufacturing company, in order to have dependable supplies of sugar cane bagasse to meet the demand for certain types of insulating material, has recently purchased several sugar cane plantations, aggregating several thousands of acres in one of the Southern states. A large wood pulp corporation, having an excess of electrolytic hydrogen, has purchased great tracts of land in Florida in order to obtain supplies of cheap peanut oil for hydrogenation. This type of absorption of agriculture by industry has been seriously proposed as one of the solutions of the present agricultural situation. Grave doubts, however, may be entertained as to the wisdom of attempting a solution in this manner. The encouragement of agriculture to cease functioning as an independent factor in our national development may bring other ills of serious concern.

The enormous amount of farm residue, a major portion of which is potentially available for industrial purposes, should receive more than passing attention in the classroom. Much of it may be used in industry for various purposes. What are the possibilities of profitably utilizing this material?

Can it not be converted into materials which may find industrial application? For every pound of grain produced, anywhere from 1 to 2 or more pounds of residual material is produced along with it. Up to the present time the agricultural leaders have been given scarcely a hint as to the latest possibilities that await new uses for this farm residue other than the enrichment of the land for which much of this material is not always satisfactory.

Already a number of industrial uses are being made of certain agricultural residues, some of which have been previously referred to. Sugar cane bagasse is being made into wallboard, straw is being used for paper, wallboard, and by destructive distillation a number of products are obtained including methanol, gas, tar, pyroligneous acid, etc. Cornstalks are being considered for paper and other purposes. Oat hulls have become an important source of industrial furfural.

The citrous by-product industry in California, already referred to, is an outstanding example of the effectiveness of effort of this sort. Several years ago, the orange and lemon growers of that state awakened to the fact that the disposition of culls and waste citrous fruits was a serious factor in the development of their business. It was costing approximately $1 a ton to dispose of this material. Application was made to the Bureau of Chemistry for aid in developing methods for converting this waste into economical products. The result was the establishment of a citrous by-product industry, producing such valuable by-products as citric acid, lemon and orange oil, pectin, and other materials with a value of about a million dollars per annum. The citrous culls and wastes, when delivered to the factory, are now returning to the growers approximately $12 a ton.

Although the citrous by-product industry was developed as a means of disposing of culls and waste material, it has proved to be a means of stabilizing the citrous fruit industry, for now when a surplus crop is produced the surplus goes to the by-product plants instead of being pushed upon the market to disturb the price of fresh fruits. The attempt of industry to solve the problems of the utilization of waste citrous fruit failed, but the coöperative work of the producers was successful. It is in connection with such coöperative endeavors of farm producers that the chemist can be most helpful. Who is better qualified than he to function as an intermediary between the farmer, the manufacturer, and the consumer? Without doubt the chemist with an agricultural background is the one most competent to trace back any inferiorities of the final product to faulty manufacture or errors in agricultural practices. He is in position, too, to suggest methods which should be adopted to remedy such defects. In many instances, he is required to function as an economist and a chemical engineer as well as an agricultural chemist. The farmer and the farm leader should have a wider knowledge of the possible uses of the products of the farm including agricultural residues.

Each year our farms produce enormous quantities of agricultural residues. Some idea of the quantity of these materials is shown by the figures that have been prepared in the Bureau of Chemistry and Soils:

Raw material	Annual production, tons
Cornstalks	100,000,000
Cereal straws (excluding corn)	115,000,000
Corncobs	20,000,000
Oat hulls	3,000,000
Cotton stalks	18,000,000
Cottonseed hulls	1,800,000
Flax straw	2,200,000
Peanut shells	70,000
Sugar cane bagasse	500,000
Total	260,570,000

At this state of our discussion it may be of interest to consider one of the largest and best-known agricultural waste products, which is straw, and make a survey of the possible uses to which it can be put. When the grain is threshed, the straw in the stack can be burned as a useless material to make way for the new crop, thus leaving on the land only the mineral ingredients of the straw, which are of small value. This method of disposing of the straw is commonly practiced in many of the large grain-producing sections of the United States and is recognized as wasteful in the extreme. If the farmer has no livestock, he may scatter the straw over the fields to be plowed under or he has the possibility of converting it into artificial manure by bacterial fermentation according to methods which have recently been developed and patented by the Rothamsted Experiment Station. If he has livestock, he may use the straw for bedding and for feed. Some 30 years ago in Germany, Lehmann demonstrated that by a chemical treatment, the digestibility and palatability of straw as a fodder might be improved. In either case, whether utilized for bedding or for feed, the straw is converted into manure which is eventually returned to the soil. The farm producer might consider briquetting the straw for use as a fuel or burning direct in a straw burner in case coal and wood are too expensive. If the section of the country produces sufficient straw for the establishment of a coöperative or independent industry, it might be worked up by destructive distillation into carbon, straw tar, illuminating gas, acetic acid, methanol, and other products. By hydrolysis he may obtain xylose or furfural, oxalic acid, etc., or by still milder hydrolysis convert the straw into paper and strawboard.

Although some of these methods of industrial utilization may be excluded for various reasons, some might conceivably be successfully employed, and with the rapidly changing conditions a knowledge of the possibilities is of special importance. The student, however, should be cau-

tioned that economic factors play a major part in the way that such material may be used. In many cases the technology has been worked out very satisfactorily, but the possibility of developing an industry depends upon many factors such as climate, location, commercial development, etc. The possible utilization of agricultural products and residues should be impressed upon the student who is specializing in the field of agriculture. Whether taught under the title of agricultural chemistry or embodied in a series of courses under other designations is of little consequence. It is true that the criticism may be made that this is not agricultural chemistry in the light of prevailing definitions, but is a phase of industrial chemistry. Such criticism is well founded but may be answered by the statement that the farmer must have and does have an interest in the industrial utilization of his products if he, as a class, is to prosper. He is waking up and is forcing the farm leaders to develop an interest. Inquiries directed to the agricultural colleges and to the U. S. Department of Agriculture indicate the lack of general information upon the subject and the opportunity for the researcher and teacher of chemistry. Two groups of scientists are taking a more active interest in agriculture, the agricultural engineer, who is studying farm machinery with the idea of reducing man-labor upon the farm, and the chemist, who is giving special attention to the industrial utilization of agricultural products and residues.

The work so far accomplished indicates the great possibilities for the future and these possibilities should be shared by the teachers of chemistry with their students who are interested in agricultural development.

The Marking of Laboratory Vessels. An interesting paper was read by Mr. A. W. Knapp at the annual meeting of the Birmingham and Midland Section of the Society of Chemical Engineers held in Birmingham, March 14th, on the marking of laboratory vessels. It had become, he said, a common practice on the part of manufacturers to leave a roughened patch on resistance glass vessels which would take a pencil mark very well, but where this roughened patch was not provided, marks could be scratched on beakers, or flasks, with diamonds. The marks, however, were not easily seen, and, on heating, there was a danger of cracking. Waterproof Indian ink had been used, but this tended to crack off the glass. Grease pencils were very useful for marking beakers, etc., but the mark somewhat easily rubbed off. To mark beakers in which butter or fat had been melted, he had found nothing so good as a colored spirit solution of shellac, used as ink.

Where one had to regraduate pipets or flasks, it was often difficult to retain a clear and distinct mark. A good method was to fill the mark with a little ordinary ink and then cover with a small amount of Canada balsam. When allowed to dry and harden, this would remain on the glass for years. For marking tins, the shellac ink described above would be found very useful. An aluminum pencil was useful for marking porcelain vessels. Cobalt nitrate was effective and much cheaper.—*Chem. Age*, **20**, 278 (Mch. 23, 1929).

SYNTHETIC AMMONIA IN THE FERTILIZER INDUSTRY[1]

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Inasmuch as synthetic ammonia does not at present appear in fertilizer ingredients of domestic origin,[2] the presentation of this subject must deal with proposals and future trends rather than with accomplished facts. This discussion could be confined to what has already been accomplished in Germany in placing synthetic ammonia at the service of the fertilizer industry and a picture could thus be drawn of what the future developments in this country may quite possibly be, without doing violence to one's imagination or credulity. But this picture represents revolution, while what the writer would prefer to deal with is ordered development. The rôle of synthetic ammonia in fertilizer manufacture can be played without revolution, can be played on the stage as now set, with benefit to the industry as now constituted, and as the means whereby the new order may be established by evolution as a substitute for revolution.

Synthetic or anhydrous ammonia is to be regarded first of all as a source of nitrogenous compounds to supplement or in part to replace those now employed in fertilizer manufacture and this undoubtedly is its principal rôle; and this rôle is of sufficient importance to justify amply the effort now being expended in the development of the nitrogen fixation industry and in the research now being conducted to further improve fixation technic.

The simplest procedure from the present status of the industry would be to market synthetic ammonia in those forms or combinations to which the trade is already accustomed and for which a demand already exists. But the simplest may not be the most logical. Instead it would appear preferable to supplement rather than to imitate or duplicate the nitrogenous compounds at present available in liberal quantity except of course those for supplies of which we are still dependent on foreign countries. This would exclude ammonium sulfate with which we are already liberally supplied from domestic sources, and would include sodium nitrate for which last year we made foreign expenditures of $30,000,000. With respect to the latter a market already exists capable of absorbing the output from extensive operations.

But sodium nitrate is subject to the same criticism that pertains to so many other of our conventional fertilizer ingredients, namely, its low concentration in elements of plant food. Its 16 per cent plant food compares unfavorably with that of so many other nitrogenous compounds that one

[1] Read before the Division of Fertilizer Chemistry at the 76th Meeting of the American Chemical Society, September 12, 1928, at Swampscott, Mass.

[2] It is to be understood that synthetic nitrogen compounds of foreign origin are now employed in considerable, though relatively small tonnage, as occasional ingredients of domestic mixed fertilizers.

is enticed to speculate and to experiment to determine whether or not we are still justified in delivering nitrogen to the fertilizer manufacturer in a container, so to speak, which weighs five times as much as the article contained. This is contrary to the practice observed in the distribution of other commodities where the rule is universal that the container shall be as light as possible and as cheap. To carry the analogy further nowhere else does one find the article or commodity distributed so firmly attached to its container that the two are inseparable, so that where the one must go the other must also. To be sure, fixed nitrogen, whether as ammonia or nitrate, must have its carrier, its container, but the container should bear a more logcial relationship in terms of weight to the nitrogen contained. In comparison with sodium nitrate with 16 per cent nitrogen or plant food, consider cyanamid, with 22 per cent; ammonium chloride, with 26 per cent; ammonium sulfate nitrate, with 29 per cent; ammonium nitrate, with 35 per cent; urea, with 46 per cent; potassium nitrate, with 60 per cent; diammonium phosphate, with 66 per cent; mono-ammonium phosphate, with 74 per cent; and potassium ammonium phosphate with 84 per cent plant food.

In this incomplete list are found compounds, all of which are familiar, their methods of manufacture are understood and their value as fertilizer materials largely determined. That they will be supplemented by other compounds is to be expected especially so as it is desirable that there be provided additional nitrogen compounds less readily soluble and less immediately available, compounds that will simulate the organics in becoming available more slowly and over a more prolonged period.

These salts represent diversification which is desirable not because there is virtue in diversification, but because it admits of elasticity in those operations where nitrogen compounds may result as side-products or by-products of other manufacture, and that brings us to a consideration of the use of synthetic ammonia as a chemical reagent.

The American fertilizer industry as now constituted may be said to center in phosphates, as the principal ingredient and as the ingredient which in general the industry manufactures for itself. The application of anhydrous ammonia in that manufacture takes its simplest form in the use of gaseous ammonia[3] as a neutralizing agent for the free acid frequently found in superphosphates (acid phosphate). This excess acidity is undesirable in its destructive action on sacks and in its chemical reaction with certain ingredients commonly employed in mixed fertilizers resulting in an alteration in the physical properties of the mixture or sometimes in the loss of plant food elements. In this use

[3] At present aqueous ammonia is being employed in increasing amounts and apparently with satisfactory results. The use of gaseous ammonia impresses the writer as being more logical.

gaseous ammonia functions not only as a neutralizing agent but in general as a conditioner, curing agent, drying agent, and as protection against hygroscopicity.

The incautious use of ammonia causes reversion from the water-soluble to the citrate-soluble form and even to the citrate-insoluble form. So long as citrate solubility is accepted as the criterion of value the primary conversion is not to be feared, especially so as the ammonia absorbed has a sales value greater than its cost. There are those who contend that the di-calcium is preferable to the mono-calcium phosphate, and certainly it has superior properties that commend it as an ingredient of mixtures.

Phosphoric acid is now produced in considerable tonnage and for fertilizer use is neutralized with phosphate rock to form a product containing 47 per cent of plant food. In this operation the gypsum which normally attaches itself to superphosphate to be sacked and transported without making any contribution on its own account, is by-passed to the gypsum pond to repose there until it can pay its way as an ingredient of cement or as gypsum block or board or in other useful form. Ridding superphosphate of the incubus of gypsum is a long step forward but is only a step to be followed ultimately by the elimination of calcium also. Combining phosphoric acid with ammonia to form the ammonium phosphates as a substitute for superphosphate and ammonium sulfate, serves the triple purpose of eliminating the calcium and the sulfuric acid of superphosphate, and the sulfuric acid of ammonium sulfate, and yields a product whose shipping container, so to speak, is only a fraction of the total weight and admits of a much wider distribution than is now possible with present products. Such products are ideal for the export trade and it is entirely logical that we, with our large deposits of phosphate rock conveniently located with respect to manufacturing facilities and seaports, should appropriate the foreign markets. With our increasing production of phosphoric acid and with anhydrous ammonia conveniently at hand at prices considerably below its fertilizer value, facilities are available for testing the potentialities in these new directions.

Anhydrous ammonia as a chemical reagent may play a further rôle in other than fertilizer industries from which, after serving its purpose there, it may reappear in a form available for fertilizer use. To illustrate by a single instance, in the extraction of potash from green sand where the potash appears as potash alum, an intermediate product, its separation, formerly accomplished by the thermal decomposition of the alum, may now be easily done by exposing the crystalline alum to an atmosphere of gaseous ammonia, whereupon alumina and potassium and ammonium sulfate result. The ammonia thus performs its function as a chemical reagent, substituting for a costly and bothersome roasting operation and is still available for the fertilizer market.

The fertilizer industry is already familiar with the use of ammonia as a source of nitric oxide in the manufacture of sulfuric acid, and with the ammonia oxidizer as a substitute for the conventional niter pot. One of my colleagues recently returned from a visit to fertilizer plants reports eleven of the twelve sulfuric acid plants seen as employing the ammonia oxidizer. This commendable new development has far-reaching potentialities in familiarizing the industry with anhydrous ammonia, its properties and the technic of its handling, and also providing supplies conveniently available for experimental work. Likewise, there is made available a ready supply of nitric oxide representing potential facilities for the manufacture of nitrates within the fertilizer plant, provided this procedure can be made sufficiently attractive to warrant the industry in undertaking that line of endeavor.

It appears to be within the realm of possibility that the ammonia thus used in sulfuric acid plants may in part be recoverable as a fertilizer product. It has been shown how nitrogen peroxide may be absorbed by phosphate rock to form calcium phosphate nitrate and in the laboratory this absorption has been shown to approach the quantitative. In the laboratory the spent gas emitted from the absorption towers contains nitric oxide in such low concentration as to be invisible, indicating an efficiency which would make recoverable a portion at least of this oxide emitted from Gay-Lussac towers despite its extreme dilution. It is estimated that this loss approximates $1,000,000 worth of nitrates per year. Assuming a 75 per cent recovery as the calcium phosphate nitrate, the sales value of the product would be something over a million.

But less visionary is the suggestion that this convenient and efficient source of nitric oxide, represented by the ammonia oxidizer be utilized for the direct production of the calcium phosphate nitrate product. By its use a ton of phosphate rock is readily converted into $1\frac{1}{2}$ tons of product of a total value of $48.00 wholesale. As a substitute for sulfuric acid, nitric oxide commends itself as yielding a product containing 26 per cent plant food as compared with the 16 per cent of superphosphate. Nitric oxide after absorption has a market value as nitrate nitrogen considerably in excess of that of the ammonia from which derived as contrasted with sulfuric acid, which after being used has no value.

Synthetic ammonia offers the possibility of terminating the fertilizer industry's present dependence on sulfuric acid whenever it is found desirable to terminate that dependence. Already it has been shown how ammonium sulfate can be produced from gypsum as a substitute for absorption in sulfuric acid, although at present this operation does not especially commend itself for American conditions. The use of nitric oxide as a substitute for sulfuric acid for rendering available the phosphoric acid of phosphate rock offers advantages on the dollars and cents basis

not possessed by present methods. Whether the technology of this operation can be satisfactorily solved remains to be seen. Results so far obtained offer the distinct promise that no insuperable difficulties will be encountered. The advantages offered would appear to justify any effort required to reduce the proposal to practical terms. The working margin between cost of raw materials and the sales value of the finished product is $21 per ton of phosphate rock in the use of nitric oxide as compared with $3.50 in the use of sulfuric acid. How much of this spread will be consumed by operating costs will depend on the skill of the technologist.

Synthetic ammonia is regarded as the keynote in the concentrated fertilizer symphony but there are those who feel that liquid phosphoric acid shares that honor. A compromise may be found in the position that both are essential. Certainly, with the two the entire concentrated fertilizer program may be brought to realization. Synthetic ammonia is an accomplished fact, available at prices below fertilizer values. The same statement cannot yet be made with respect to phosphoric acid if we restrict our consideration to the domestic situation. What has been done abroad we can do here and will do when and if it suits our purposes. In the meantime, we are proceeding logically with our concentrated fertilizer program, taking the initial steps toward more concentrated mixtures with the materials already available and with these preliminary mixtures gaining the experience necessary before proceeding to the most concentrated. The technic of manufacture and of distribution is being studied. Field tests are being conducted. A noteworthy tonnage of fertilizers analyzing 60 per cent plant food is being marketed. The low analysis mixtures only a few years ago regarded as the standard are now disappearing from the market. The freight bill paid to move the 7 million tons of fertilizer used annually in American agriculture amounts to approximately $20,000,000. The sacks used to contain it cost an additional $12,000,000, a total of $32,000,000 to be cut in two with the doubling in the plant food content of prepared fertilizers from 15 to 30, or from 20 to 40 per cent. The limit does not have to be reached before the benefits begin to accrue. Each step brings its own reward.

Diatomaceous Earth. Diatomite has hitherto been mined only in very small quantities in Nova Scotia, but it is likely before very long to become a product of some importance in Canada. Recently a deposit of large magnitude, stated to be the richest in eastern Canada, has been under development at Digby Neck. Diatomaceous earth has for many years been extracted in small quantities by the Oxford Tripoli Sales Company in Colchester County, and the Company has also installed a new plant at East New Annand where they have located four large bogs containing a big tonnage of diatomite.—*Chem. News*, **138**, 116 (Feb. 22, 1929).

CONCENTRATED FERTILIZERS: PROBLEMS FOR THE CHEMIST AND AGRONOMIST[1]

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The farmers of northern Europe and eastern United States have inherited an agriculture whose principal crop plants were introduced from regions where the soil was fairly well supplied with soluble salts. Working soils developed under humid conditions, these farmers have had a constant and often losing struggle to supply through the medium of the soil sufficient soluble salts for optimal growth. Many are the unrecorded tragedies of unsuccessful farming that have occurred on the depleted soils of humid regions. Satisfactory yields of wheat, maize, and potatoes cannot be secured without a greater supply of soluble salts than is commonly found in the tilled soils of humid regions. Intensive culture, needed to supply food to a constantly increasing population, has accentuated the demand for certain soluble salts known commercially as fertilizers.

Historical

The use of fertilizers has passed through two rather distinct periods or stages, and is now entering a third. These periods are sometimes referred to as fashions, but in reality they in the main represent economic changes made possible and necessary by advances in science. In a prize essay on "manures" written in 1843, a Massachusetts man by the name of Dana[2] wrote: "But there is a fashion in manures as well as in other things, and saltpeter is now so fashionable you may be inclined to use it." This was written at the time Chilean nitrate was becoming established as a commercial fertilizer. Prior to this there had been very little advance in fertilizer practice since the days of the ancient Roman Empire. It may be said, therefore, that the first period in fertilizer usage extended from the time of earliest recorded agricultural history until 1840, the year in which Liebig made his memorable statements regarding the relation of chemistry to agriculture. In this period comparatively low-grade and low-analysis materials such as animal manures, composts, organic wastes, bones, gypsum, marl, lime, ashes, etc.,[3] made up the main supply of materials added to the soil for its amelioration.

In the second period, 1840 to 1920, commercial fertilizers carrying 10 to 20 per cent plant food in mixtures and more or less as single materials,

[1] Presented before the Fertilizer Section of the American Chemical Society, Swampscott, Massachusetts, Sept. 12, 1928.

[2] Dana, Samuel L., "Essay on Manures," Samuel N. Dickinson, Boston, **1843,** p. 32.

[3] Guano has not been included in this group, for while guano was received both in this country and Europe it did not assume any significant commercial value until the year 1840 when the first large shipment was sent to England. Immediately thereafter English and European consumption of guano increased very rapidly.

became important. To the list of materials were now added mined products more concentrated in soluble salts than were formerly commercially available. This period saw the rise and fall of the natural guanos as commercial commodities. It was during this period also that the superphosphate industry was originated and the potash mines of Germany were exploited. This is the period during which the present extensive fertilizer industry of Europe and America was built up. It was in 1869 that Stockbridge[4] began his experiments with the soils of the farm of the Massachusetts Agricultural College, which finally led to his recommending the use of so-called complete mixed fertilizers. His work was an important factor in the foundation of our American fertilizer industry. It is interesting to note here that recently certain fertilizer interests in Europe have begun to promote the use of "complete" fertilizers. This second period is also the period to which Shaler,[5] the great geologist and student of human progress, referred when he stated that the rapid advance in the use of fertilizer "may fairly be reckoned as the most significant of the great winnings of the last half century."

Some of us are inclined to think that the problems of concentrated fertilizers are new in this generation. At least in the minds of the preceding generation there was a situation with respect to concentrated fertilizers of that time, as shown by references to the agricultural writings of 50 to 60 years ago. Goessmann[6] referred to them in 1873, and Flint, the secretary of the Massachusetts Board of Agriculture, wrote in 1874: "The modern use of concentrated fertilizers has grown up chiefly from this necessity" (referring to the necessity of supplying phosphorus and potassium to soils which had become deficient in these elements by cultivation). Problems arising during this second period were not very unlike those now arising with our new concentrated fertilizers.

About the turn of the last century there were made several important discoveries of chemical processes and commercial application of them, which have culminated in the present gigantic and rapidly expanding nitrogen-fixation industry. In this connection it is only necessary to mention in passing the epochal work of Frank and Caro, Birkeland and Eyde, Haber and Van Oordt[7] and many other chemists, physicists, and engineers who have contributed to our present knowledge of production methods. The first synthetic ammonia was produced in 1910: the Oppau works were built in 1913, and due to the stimulation of the war developed a producing capacity of 130,000 tons ammonium sulfate by the close of 1915.

[4] In 22nd Annual Report of the Massachusetts Board of Agriculture for 1874, p. 76.

[5] Shaler, N. S., "Man and the Earth," Duffield & Co., New York, **1912,** p. 133.

[6] In 21st Annual Report of the Massachusetts Board of Agriculture for 1873, p. 129.

[7] Waeser, B., "The Atmosphere Nitrogen Industry." Translation by E. Fyleman, P. Blakiston's Son & Co., Philadelphia, **1926,** Vol. 1, p. 42.

In 1918–19 the Oppau works produced about 70,000 tons fixed nitrogen. By 1920 synthetic nitrogen products had become abundant and cheap enough to become a factor in the world's fertilizer consumption. We may then fairly say that the year 1920 marks the beginning of the third period of fertilizer usage. By this time the commercial production of some of the most highly concentrated fertilizer materials yet used, such as ammonium phosphate, ammonium nitrate, urea and treble superphosphate, had gotten under way.

It is significant to the fertilizer industry that this meeting of the American Chemical Society is featuring the centenary of Wöhler's synthesis of urea, one of our most promising concentrated fertilizer materials. Synthetic nitrogen products have already exerted a marked effect on the fertilizer industry, and are beginning to make an impression on agricultural practice. There is little doubt that agriculture of humid regions will be profoundly influenced during the next generation or two by the use of lower-priced synthetic nitrogen fertilizers. Goessmann[8] wrote prophetically when he stated 55 years ago: "An economical way to force the nitrogen into a chemical combination with either oxygen, hydrogen or carbon, has still to be discovered.....The successful solution of that problem will eventually affect the agricultural industry far more than at first glance might be presumed."

Experiments and Experience

Sufficiently extensive tests of concentrated fertilizers have now been made in this country and Europe to prove that such materials can successfully compete with the low-, and medium-analysis materials of more common usage. It is only necessary to mention in passing the tests conducted by the New Jersey Station, the extensive tests by the U. S. Department of Agriculture, those by the Massachusetts Station and others under way in Connecticut and elsewhere. Some of these are being reported at this meeting. To the evidence gained by the experiment stations has now been added a considerable body of experience by farmers. It is interesting to note that the highest yield of potatoes ever officially recorded as made with concentrated materials—a yield of 1038.3 bu. with an 0–23–24 fertilizer.[9] Double-strength fertilizers are being used extensively for potatoes in New England. It has been reported that there is one factory in New England catering especially to Aroostook potato growers, which will mix only double-strength fertilizers this coming season.

For New England conditions at least, the agronomic evidence for con-

[8] Goessmann, Chas. A., "On Some Home Resources of Fertilizers—with Particular References to Nitrogen Plant-Food." In 21st Annual Report of Massachusetts Board of Agriculture for 1873, pp. 112–30.

[9] *Fertilizer Review*, **2**, 1 (Jan., 1927).

centrated fertilizers as a class is low strong enough that we may safely say that the future depends on economics. There will, of course, be found exceptions: some concentrated materials will not be satisfactory; some will be unsatisfactory under some conditions of soil and climate, satisfactory under others—as we have found with the more dilute materials. In our opinion there is no real conflict between concentrated and dilute fertilizers aside from economics. We hold no brief for concentrated fertilizers as against others. The Massachusetts Station has taken the stand that, everything else being equal, we shall recommend those materials which allow the farmer to place a unit of plant food in the soil at the lowest cost.

It is unfortunate from the standpoint of introduction of new materials that the word *concentrated* has been so widely applied to them. Artificial fertilizers have always had to live down prejudice when first introduced. The word *concentrated* in connection with fertilizers connotes to the layman a strong probability of plant injury. A terminology involving the words *low-*, *medium-*, and *high-analysis* would seem less objectionable and more accurate.

High-analysis fertilizers have brought problems for the chemist and agronomist which are not unlike many of the problems that arise with the lower-analysis materials. We shall have to go through some of the stages of testing and experimenting that were passed through 50 to 60 years ago. It is to be hoped that the body of knowledge then and since built up will be used to advantage.

Problems and Opportunities

Some of the outstanding problems and opportunities now before us are:

1. The significance of certain elements as stimulants or poisons of crop plants needs determination.

The precise rôle in plant nutrition of such elements as manganese, copper, zinc, and boron must be determined. At what concentrations are they toxic? Where does maximum stimulation occur and how? What is the behavior in soils as compared with water cultures? What relation do soil reaction and other soil conditions bear to their activity? These are common ground for the chemist, physiologist, and agronomist. Considerable progress has been made. Here the work of Brenchley, McHargue, Conner, and many others[10] need only be mentioned. Already we know from work done that there is no universal complete fertilizer now made. Which, if any, of the rare-element compounds shall the fertilizer manufacturer add to his mixtures to obtain something that approaches

[10] Brenchley, W. E. "Inorganic Plant Poisons and Stimulants," 2nd ed., University Press, Cambridge, 1927.

a complete fertilizer, when the purer forms of both low-, and high-analysis materials, synthetic or otherwise, are used?

2. Determination of soil conditions under which it is necessary to supply certain nutrient elements not commonly contained in fertilizers but known to be important in plant nutrition is necessary.

Garner and co-workers[11] have reported a magnesium deficiency in certain soils of North Carolina on which tobacco was grown. The deficiency was evident when the common purified carrier of potash was used, the sulfate, but not with the less pure muriate. Magnesium deficiency produces in tobacco physiologic symptoms known as "sand drown." This nutrient deficiency has been noted in certain tobacco soils of the Connecticut Valley, and recently Jones[12] has proved it to be the cause of chlorosis in corn grown at the Massachusetts Station. Corn appears to be a better diagnostic plant than tobacco for magnesium deficiency. This case is interesting because it occurred on two adjoining fields, one receiving the common fertilizer materials, nitrate of soda, dried blood, dry ground fish, acid phosphate and muriate of potash, and the other recently one of the new highly concentrated fertilizers. Magnesium deficiency can be overcome by the use of magnesium sulfate. Similarly, no doubt many of the cases of response to lime are due to the supplying of deficient nutrient calcium. Here again in such cases of nutrient deficiency the chemist and agronomist must work together to develop diagnostic methods and find suitable specific remedies.

3. The tolerance of various crop plants for new materials and the growth response under optimum conditions must be found out.

The question of "burning" ordinarily has loomed large in the mind of the layman. Experience of the last few years has proved that there is very little if any more danger likely to occur from the use of high-analysis than from the low-, and medium-analysis goods. The method of application has a distinct bearing on this question with both concentrated and dilute materials. For example, at the Massachusetts Station we found that sweet corn would stand as much as two tons of highly concentrated nitrophoska (16–32–16) broadcast without injury, but the same amount per acre applied in the row was disastrous.

One portion of a tobacco field treated with nitrophoska (16–32–16) has shown a very peculiar and puzzling condition which has not yet been satisfactorily explained. The tobacco was stunted and showed symptoms of certain nutrient deficiencies as well as actual toxicity. The affected

[11] Garner, W. W., *et al.*, "Sand Drown, a Chlorosis of Tobacco Due to Magnesium Deficiency, and the Relation of Sulfates and Chlorides of Potassium to the Disease," *J. Agric. Research*, **23**, 27–40 (1923).

[12] Jones, J. P. Unpublished data of Massachusetts Agricultural Experiment Station.

area was subjected to considerable sheet erosion. One row later top-dressed with our standard medium-analysis mixed fertilizer showed almost complete recovery; but a parallel row which received a top-dressing of nitrophoska showed no signs of recovery. The greater part of the field which received the concentrated fertilizer grew good tobacco. What is the explanation?

4. To the chemist falls the tasks of perfecting methods of manufacture of materials of known or promising value and of creating new materials.

This applies not only to the commonly known materials such as nitrates, ammonium salts, and urea but also to the great group of slightly explored organic nitrogen compounds. What about the commercial possibilities of many amino and amide compounds which have been found[13] to be absorbed directly by the plant or else rapidly nitrified in the soil? Some of these are now so expensive as to be almost prohibitive even for research work. Some of them are only slightly soluble in water, a property which may be an asset under some conditions.

To the chemist also is given the opportunity and the challenge of creating entirely new fertilizer materials, both inorganic and organic. This is one of the most enticing fields for the creative chemist. The present commercial trend is to find the correct fertilizer for every plant, soil, and climatic condition. Who is going to be the first chemist to give us a synthetic substitute for dried blood? It does not need to be a protein, some simpler nitrogen compound will do; perhaps an amino acid that is slightly soluble in water, decomposes and nitrifies readily in the soil, and has a good physical condition. Is it possible to synthesize a product which happily blends the properties of Bakelite and urea?

5. The effects on the soil of continued application of the new materials must be determined.

Experience of the past with some of the older materials has proved that deleterious soil conditions may result from the continued use of certain fertilizers. This is a joint problem for chemistry and agronomy to be worked out as soon as may be practicable.

6. Methods of applying fertilizer so as to secure uniform distribution and optimal growth conditions need further study.

This is primarily a problem for the agronomist and engineer but it has its chemical aspects.

7. Finally, there is a group of physical-chemical problems having to do with the physical properties of fertilizers.

How may undue hygroscopicity and cakiness of certain otherwise desirable materials be reduced or prevented? Successful storage and drillability of materials depend on these properties. Also the question of undesirable chemical reactions in mixtures is concerned with them.

[13] Batham, H. N., "Nitrification in Soils," *Soil Science*, **20**, 337–51 (1925).

In conclusion, it is desired to point out the need of a coöperative alliance between chemists and agronomists on the problems of high-analysis fertilizers. Can a working program of research be formulated? As Mr. F. C. O. Speyer aptly put it at the "Luetzow" International Nitrogen Conference: "Scientific research must be pursued continuously, lavishly, and relentlessly."

COLLOIDAL CONTENT OF CLAYS

Study of Grain Size Distribution. Included in the program of the China Clay investigation of the United States Bureau of Standards is a study of grain size distribution. While this has been carried out by the sedimentation process and application of Stokes' law down to a particle size diameter of 1.7 microns, the data indicated that from 35 to 60 per cent of the total clay had a grain size of less than 1.7 microns. Since this large quantity of finely divided material undoubtedly has a pronounced effect upon the properties of the clay, it seemed desirable to make a further classification as regards size.

After reviewing the literature and studying the methods of various investigators, it was decided that centrifuging was the best way to effect the separation. Hand- and motor-driven centrifuges were tried, but the speed was insufficient and a Sharples laboratory super-centrifuge was obtained. It was found that for a suspension of specific gravity 1.6 and a range of flow of 20 liters per hour, the centrifuge would throw out of suspension all particles greater than one micron in diameter when rotating at 12,000 r. p. m.

The particle size was checked with a microscope using a 12.5 micrometer eyepiece and an oil immersion objective. The second separation consisted in taking the suspension from the first and centrifuging it at a speed of 18,000 r. p. m. and a rate of flow of about 8 liters per hour. This material remaining in suspension after the second separation was removed either by centrifuging at 40,000 r. p. m. and a very slow rate of flow, or running through a set of Pasteur-Chamberland filters. The ultra-filters have a slight advantage over the centrifuge in that they remove every particle of suspended matter while the centrifuge leaves a trace in suspension.

Adsorption of Water. The Bureau of Chemistry and Soils has done considerable work on the estimation of colloidal material by obtaining the adsorption of water or other liquids, by the clay, and by a sample of the total colloid. The adsorption in grams per gram of the total clay divided by the corresponding value for the total colloid gives the percentage of colloid. This method will be used to estimate the total colloid present in the clays. The figure obtained should check roughly the amount indicated in the earlier work as being under 1.7 microns.

Then, to go farther, it is desired to compare the quantities of material obtained from the second and final extractions of any one clay with like quantities from any other clay. If the same volume and the same concentration of suspension are used for the various clays, then, under similar conditions of centrifuging, the actual amounts of material thrown out at any one speed should be relative and comparable. The separated material can be carefully removed, dried, and weighed.

Thus far data have been collected on a few clays only, but it is expected that considerable difference between one clay and another will be shown in the quantities of these fractions.—*Chem. Age*, **20**, 253 (Mch. 16, 1929).

SOME CRITICISMS OF THE CURRENT TEACHING OF INORGANIC CHEMISTRY

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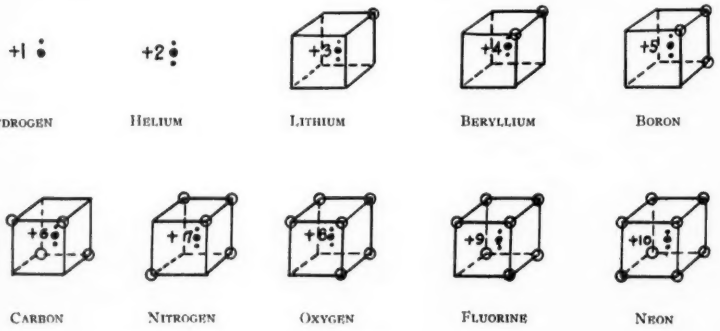
The growing prominence of research on the problems of atomic and crystal structure and the rapid developments in these fields have forced authors of textbooks on inorganic chemistry to give some consideration to the subject if any hope is entertained of giving anything like a modern view of the state of physical and chemical science. Some have done so hesitatingly, giving the impression to the student mind that in this very little is surely known. Some give only a little space to atomic structure theories and their experimental background, with the effect of minimizing their importance and value in explaining the facts of chemistry. A few writers do indeed give creditable and clear presentations of present-day knowledge in regard to atomic structure, and a somewhat smaller number have actually attempted to apply modern views to the explanation of chemical phenomena. With some pleasing exceptions it is the nearly universal practice in the current textbooks to give views on atomic structure proposed ten years or more ago and long since modified or abandoned by their original proponents.

Plane Ring Configurations

J. J. Thomson[1] first proposed in 1904 a ring system in which electrons were distributed in a system of concentric rings lying in one plane. He



calculated the number of electrons which might exist stably in successive rings and the distribution of these electrons in the various rings. The *corpuscles* (electrons) were assumed to be contained in a sphere of uniform positive electrification. Thomson himself admitted that the electrons

[1] *Phil. Mag.*, **7**, 237 (1904).

were almost surely distributed in three dimensions, and stated that the only reason for his plane representation was his inability to carry through the difficult mathematical calculations involved in such a three-dimensional system. Kossel[2] in 1916 advocated a modified ring system.

The most obvious criticism of such a system is that a ring of symmetrically distributed electrons revolving in circular orbits at a fixed distance from a positively charged attracting center would be unstable and on account of the mutual repulsions of the negatively charged electrons would tend to give place to a symmetrical and more stable distribution on the surface of an imaginary sphere.

The Octet Theory

The majority of textbook writers restrict their treatment to a statement of the so-called "Lewis-Langmuir Theory," as proposed by G. N. Lewis[3] in 1916 and modified by Irving Langmuir[4] in 1919 in his famous paper on "The Octet Theory." The theory is variously described as "the chemist's picture of the atom," "the octet theory," "the Lewis-Langmuir theory," "the cubical atom theory," and "the static theory of atomic structure." It is stated in the texts as originally outlined, and the student is led to believe that he is being introduced to the very latest developments in this field, when, as a matter of fact, neither Lewis nor Langmuir now holds in unchanged form the views attributed to them and no well-informed chemist thinks in terms of these outgrown pictures.

In some cases the theory is stated dogmatically. In others it is introduced by a brief mention of the outstanding developments in the study of atomic constitution prior to 1916.

Brief Statement of the Octet Theory

According to the earlier views of Lewis and Langmuir the extra-nuclear electrons occupy fixed positions at the corners of concentric cubes. The electrons in any one cube may be considered to lie symmetrically throughout a spherical *shell* circumscribed about the cube. According to Langmuir's 1919 paper each *shell* has thickness and is divided into a fixed number of compartments, each of which may be occupied by either one or two electrons. The first few atomic models are represented thus:

The properties of the atom depend largely on the number of electrons in the outermost, *valence*, shell and area ccounted for by the "tendency" of

[2] *Ann. der Physik*, **49**, 229 (1916).

[3] *J. Am. Chem. Soc.*, **38**, 762 (1916); *Proc. Nat. Acad. Sci.*, **2**, 586 (1916); see also *Science*, **46**, 297 (1917).

[4] *J. Am. Chem. Soc.*, **41**, 868, 1543 (1919); **42**, 274 (1920); *J. Franklin Inst.*, **187**, 359 (1919); *Proc. Nat. Acad. Sci.*, **5**, 252 (1919). See also Hendrick, *Met. Chem. Eng.*, **21**, 73 (1919) for a statement of the theory.

the atom to surround itself with an outermost shell of eight electrons, this *octet* of electrons furnishing maximum stability. The periodic recurrence of properties is therefore correlated with the formation of successive outer shells of eight electrons.

Atoms with 1, 2, or 3 valence electrons "tend to lose" these so as to leave an outermost shell of eight electrons; these elements, then, are electropositive, easily forming positive ions. That part of the atom left after all valence electrons are gone is called the "kernel." Those atoms with 5, 6, or 7 valence electrons "tend to gain" additional electrons to complete their valence octets and are therefore electronegative atoms, easily forming negative ions. Abegg's rule is accounted for by saying that an atom may either lose all of its valence electrons (in which case it exhibits a corresponding *positive* valence) or gain enough electrons to complete its octet (in which case it shows a *negative* valence equal to the number of electrons gained). The sum of the corresponding maximum valence numbers is obviously eight.

Chemical combination is supposed to take place in either of two ways. In a *polar* union (of binary type, for example) an electropositive atom has lost its valence electrons to an electronegative atom and the two *ions* are held together by electrostatic attraction. In a *non-polar*, or *semi-polar* (binary) union electrons have not actually been transferred from one atom to another, but the two atoms have come close together so that one or more valence electrons of one atom occupy previously unfilled positions in the valence shell of the second atom and thus octets are completed by this process of sharing. Langmuir has applied the name *co-valence* to this type of union.

Criticism of the Theory and Its Presentation

1. Orientation of Electrons in Incomplete Octets.—In the usual diagrammatic models electrons are arbitrarily assigned to imaginary cube corners without regard to the effect of mutual repulsion of the electrons as a factor in determining the distribution in a given shell. Beryllium atoms are usually shown with two valence electrons at adjacent corners. Now if electrons within the atoms still repel each other, they would if placed in such positions move away until a maximum distance apart. They would then occupy diagonally opposite corners of the cube. Similarly, the usual boron arrangement of three electrons at corners of the same imaginary face would be unstable.

In the case of carbon maximum stability (minimum potential energy) would be attained if the four valence electrons were arranged at those corners of the cube which would form the corners also of an imaginary regular tetrahedron.

In the case of oxygen, however, it is impossible to reconcile cubic arrangement with maximum symmetry and stability of the system. Six electrons

at a constant (or equal) distance from an attracting center will have minimum potential energy only if they are in positions corresponding to the corners of a regular octahedron, and there is no arrangement at cube corners which is compatible with this requirement.

The ordinary laws of electrostatics and the tendency of any system to assume a condition of minimum potential energy must therefore be abandoned if we are to postulate cube corner distribution.

2. Relative Orientation of Successive Shells.—Most cubic models of atoms heavier than fluorine show the corners of the concentric cubes to be similarly oriented, so that the corresponding corners of successive cubes lie on the same straight line. Thus arranged, electrons are at a *minimum* distance from each other and in order to achieve stability the system would have to rearrange so as to put each electron as far as possible from all neighboring electrons.

It may be remarked in passing that this requirement would be met only when each electron was opposite the center of a face of the cube just inside or outside its own, and such an arrangement is impossible for cubs which have *eight* corners but only *six* faces.

3. Triple Bonds.—According to the usual method of representing atomic combinations, single-bonded union corresponds to two cubes with one edge in common and a double bond to two cubes with one face in common. It is impossible to represent or account for triple bonds by this theory, since it is impossible for two separate cubes to have two faces in common as would be required by the extension of the sharing principle to triple-bonded unions.

4. The Stable Octet.—It is indeed true that as we compare the properties of the elements in relation to the structural representations of their neutral atoms we find great stability and chemical inertness in those cases where the theory has led to the assignment of outermost shells of eight electrons; namely, in the cases of the inert gases. That this octet of electrons is especially stable is further evidenced by the fact that in the formation of positive ions by elements in the two *short series* of the Periodic Table the process stops when all the valence electrons have been removed; the underlying octet (or *stable pair* in the cases of the elements sodium to fluorine) is not attacked. In addition, the formation of negative ions by any of the elements ceases when, according to the theory, electrons have been added to the valence shell in sufficient numbers to complete an octet.

It should be noticed, however, that an octet of electrons is apparently not the *only* stable grouping. Compare, for instance, the number of electrons in the outermost kernel shells of many positive metallic ions (*e. g.*, Zn^{++}, Ga^{+++}, Ge^{++++}, As^{+++}, Fe^{++}, Fe^{+++}, Mn^{++}, Co^{++}).

A second objection to laying stress on the formation of stable octets

is that the regularity breaks down after the first two (*short*) series of elements and the simplicity of explanation of valence and chemical properties in terms of "the law of octaves" has to be abandoned. The significance of the octet therefore is limited to its occurrence in the valence shell. Some writers fail to make this distinction clear because they confine their discussions to the structures and properties of the "short series" elements.

Tendency to Lose Electrons

On the basis of the foregoing evidence for the stability of outermost shells of eight electrons the writers of textbooks almost without exception state that every atom "tends to lose or gain electrons" until a stable octet is achieved. The more electropositive elements are said to have a "greater tendency to lose electrons," and the more electronegative elements a "greater tendency to gain electrons."

The present writer believes that such expression (and many other more anthropomorphic designations) deserve criticism and should be replaced by a more fundamental statement in terms of actual forces holding electrons within the atoms.

For example, the decreasing electropositiveness of the elements lithium to fluorine is explained by saying that the valence electrons are held with greater force as the kernel charge (considered roughly as a point charge at the center of the atom) increases by one unit from element to element. The "tendency" of an atom to "lose" electrons is always relative to some external force which tends to pull electrons away from the system. Neutral atoms do not spontaneously lose electrons, as they would if *actually* possessed of a "tendency to lose." When sodium atoms combine with chlorine atoms to form an "ionized" sodium chloride crystal structure, the fact that the valence electron of a sodium atom has been transferred to the valence shell of a chlorine atom is not due to the "tendency" of the sodium atom to lose an electron but to the greater attraction for an electron exerted by the chlorine atom, which has a kernel charge six units greater than that of the sodium atom.

Electron Pairing and Tetrahedral Distribution

The prominence given in present-day textbooks to cubic distribution as representing the last word in modern structure theory would tend to give the student the impression that all chemists are firm believers in the unchanged "octet theory," that all physicists cleave single-mindedly to the Bohr theory, and that there is little possibility of reconciling the two. As a matter of fact the developments in structure theory have been in the direction of a composite harmony of the so-called "static" atom and the "dynamic" Bohr atom.

In the later views of Lewis[5] the "position" of an electron is defined as a mean position of the electron revolving in one or more orbits (though not necessarily about the nucleus as a center), the dimensions of the "shells" in which the electrons (or their orbits) are distributed are made to agree with the dimensions of the energy levels of the Bohr theory, and the distribution of electrons at cube corners gives way to a doctrine of the pairing of electrons and the distribution of these pairs in each energy level at the corners of a regular solid. The cubically arranged octet of the rare gases, for example, is replaced by a tetrahedral arrangement of four pairs.

Valence Definitions

It is a very common practice at the present time to define valence entirely in terms of electron transfer:

> The number of electrons lost or gained by an atom is identical with its valence number.
>
> Hence we recognize two kinds of valence, positive valence due to loss of electrons and negative valence due to gain of electrons.
>
> When chemical union takes place between two elements, a valence electron passes from one element to the other.

Such definitions are strictly correct only when applied to more or less *polar* unions, where there is believed to be a definite displacement of electrons from one atom to another with resulting segregation of electrical charge. There are, however, intermediate states of combination where the electron pair occupies a position between that of non-polar sharing and complete transfer. In these cases one element may be said to be slightly more positive than the other. The definitions are entirely inapplicable to strictly non-polar combinations.

Oxidation and Reduction

The explanations of oxidation-reduction reactions have passed through interesting developments in recent years. Earlier textbooks posited the intermediate formation of *nascent* oxygen or hydrogen, these being the active oxidizing or reducing agents. More lately it has become the general practice to avoid the statement of any particular mechanism and to discuss oxidation and reduction in terms of valence changes in principal elements. The most recent development is the interpretation of oxidation and reduction as due to electron transfers. Oxidation is defined as *loss of electrons*, and reduction as *gain of electrons*. It has been proposed that the term *oxidation* be replaced by *de-electronization*.

It is indeed true that every oxidation-reduction reaction is the po-

[5] Lewis, "Valence and the Structure of Atoms and Molecules," Chemical Catalog Co., New York, 1923.

tential basis of an electrochemical cell. Where it is possible to carry out the oxidation and reduction reactions separately in a suitable cell, an electron flow is actually realized in the external circuit and the net result of the cell reaction is an electron transfer from the substance oxidized to the substance reduced.

The weakness in the current definitions, as has been pointed out by Professor Huggins, is that while electron transfer from one *substance* to another is a valid definition it is highly improper to localize every *loss* or *gain* of electrons on some particular *element* and to assign definite positive and negative charge to every such element in the combined state. As simple valence numbers arrived at by an arbitrary, arithmetical rule, such designations of positive and negative valence are useful in equation balancing, but one is not justified in assigning a physical meaning to these numbers in every case and in assuming, for instance, that every atom designated *positive* in a formula has actually lost electrons. Such conditions only exist in the polar types of union or in cases where there is evidence that the bonding pairs have been markedly displaced from one atom toward another. In the permanganate ion, for example, the Mn-O unions are only slightly polar; the manganese atom has *not lost seven electrons*, and is *not* positively charged—certainly not in the same sense as the bi-positive manganous ion, Mn^{++}, which results from the reduction of the permanganate ion.

Structural Formulas

Valence bonds acquire a somewhat different meaning in the light of the ideas explained in this paper. The standard valence numbers were originally arrived at by experimental determination of the ratio of combining (equivalent) weights and atomic weights.[6] We have hitherto conceived atoms to be held in combination by *valence bonds* equal in number to these experimentally determined valence numbers. These bonds have been variously represented; as mechanical connectors, or hooks, as attractive forces localized on specific portions of atomic *surfaces*,[7] as cohesive forces at the faces of regular solids,[8] as electrostatic attractions,[9] and in other ways. In all of these representations of atomic combination it has been assumed that each atom was possessed of as many bonds, or units of attrac-

[6] See discussion of valence by Alexander Smith in "The Teaching of Chemistry and Physics," by Smith and Hall, Longmans, Green and Co., New York, **1902,** pp. 162–4.

[7] **Stark,** "Prinzipien der Atomdynamik. III. Die Elektrizität im Chemischen Atom," Hirzel, Leipzig, **1915.**

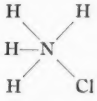
[8] Price, "Atomic Form with Special Reference to the Configuration of the Carbon Atom," 2nd ed., Longmans, Green and Co., New York, **1926.**

[9] Berzelius, "Essai sur la théorie des proportions chimiques et sur l'influence chimique de l'electricité," Méquignon-Marvis, Paris, **1819.**

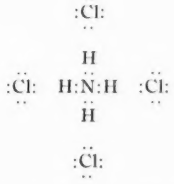
tion, as its valence number—which we have shown is merely an arithmetical concept based on combining proportions. Thus oxygen is always represented with two bonds (sometimes with four in *oxonium* compounds), hydrogen with one, nitrogen with three or five, carbon with two or four, and so on. On this basis the traditional structural formulas have been built up.

However, the actual arrangements of combined atoms in many solid substances have been determined experimentally by the methods of x-ray photography and in addition some conclusions have been reached as to the probable distribution of valence electrons.[10] In the light of these results many of the commonly accepted structural formulas are incorrect.

Consider, for example, that the usual structural formulas of ammonium compounds have shown nitrogen with five valence bonds, as in ammonium chloride,



In both crystal forms of solid ammonium chloride the units of combination are NH_4^+ ions and Cl^- ions. The ammonium ions are composed of nitrogen atoms each surrounded tetrahedrally by four equivalent hydrogen atoms. Each NH_4^+ unit is held by electrostatic attraction to four Cl^- ions, also tetrahedrally arranged. In the form stable at ordinary temperatures the hydrogen atoms are on the center-lines joining the nitrogen and the chlorine atoms.



If the chlorine atom can properly be said to be bonded to any atom in particular, it is certainly bonded to the hydrogen atom and not to the nitrogen atom. The valence of nitrogen in ammonium compounds is thus seen to be 4.

The foregoing discussion, though perhaps open to counter-criticism at many points, will serve to indicate some of the features of the current teaching of inorganic chemistry which the writer believes need to be reconsidered and revised.

[10] Huggins, "Evidence from Crystal Structures in Regard to Atomic Structures," *Phys. Rev.*, **27**, No. 3, 286 (1926). See also THIS JOURNAL, **3**, 1110, 1254, 1426 (1926); **4**, 73, 220 (1927).

THE FRESHMAN CHEMISTRY COURSE WITH PARTICULAR REFERENCE TO THE LABORATORY WORK*

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The proper correlation of secondary school and college chemistry courses has never been a simple matter. Many secondary school teachers feel that the colleges expect, perhaps require, far too much of the entering student, while, on the other hand, some college instructors pay so little attention to secondary school courses that they put beginners and students presenting chemistry for admission to college in the same class. Most educators are agreed that unless the secondary chemistry student is given credit for his earlier work in some way or other he is subjected to an injustice. If the college course for those presenting chemistry presupposes a knowledge equivalent to that called for by the college examination board syllabus and students are demoted to a simpler course if they cannot maintain the pace, the well-prepared student will be enabled to profit by his training and the handicap of deadwood be removed from the course.

If two freshman courses are to be given, some scheme for dividing the class must be arrived at. At Wesleyan two courses are offered—*B*, for those who presenting chemistry expect to take more, *A*, for all others. *A* is a modified pandemic course, not too difficult for beginners, yet with enough new features to make it a real course for those who already have some acquaintance with chemistry. The laboratory work is so arranged that those who have already had a course in chemistry will not be called upon to repeat experiments previously carried out. Considerable stress is laid on lecture demonstrations in this course, and visual educational means are extensively employed. A member of this course who decides to take more chemistry must take a semester course in the second half year devoted to theoretical topics. If the decision to go on with the subject is not made prior to the mid-year period, the student is penalized in point of time and must take *B* or the course in theory the next year, unless he can show, by examination, his fitness for qualitative analysis or organic chemistry. Students not infrequently fail to appreciate that they are subject to the general rule that failure to arrive at a decision involves a penalty, here exacted in an expenditure of time or energy in preparing for an examination to demonstrate ability to proceed with advanced courses in chemistry.

This paper deals especially with section *B*, previously mentioned. In this course lectures, recitations, and laboratory work are the main features. Relatively little attention is paid to lecture demonstrations, though a few experiments, which are particularly helpful in clarifying some of the theo-

* Read before the Division of Chemical Education at the 76th Meeting of the American Chemical Society, September 12, 1928, at Swampscott, Mass.

retical material, are introduced. A textbook is utilized. This fact deserves more than a word. A perusal of recently published books shows that they fall into two classes. The one is much like the older descriptive texts and general chemistry books, while the other class of "modern" texts stresses principles and is based on the assumption that the student is already acquainted with chemistry. Hence it emphasizes chemical relationships and really teaches *inorganic* chemistry. To my mind this is quite different from teaching descriptive chemistry or the old encyclopedic, general chemistry, so called.

Failure to teach inorganic chemistry is the worst sin to be laid to the door of many freshman chemistry courses. The students may know what a blast furnace looks like and recall the number of gallons of gasoline used in one year, but they will rarely evidence a real grasp of the broad relationships which indicate a thorough appreciation of the study of metals and non-metals. A sad lack of a knowledge of inorganic chemistry is evidenced by those enrolled in every course for which freshman chemistry is a prerequisite. Six students out of thirty in a summer course in organic chemistry, which I recently conducted, did not recognize that the white precipitate, caused by passing the products of combustion of sugar into lime water, was calcium carbonate. They could not write oxidation and reduction equations with anything approximating facility. The calculation of theoretical and percentage yields of products, involving only simple equations, they found difficult. Molecular weight and formula problems seemed mysteries to many. All of these subjects, any teacher of freshman chemistry would expect his students to be familiar with. The facts were the more striking since the class to which I refer happened to be made up of students representing a broad geographical distribution of colleges, not less than seven, wherein their freshman courses had been taken.

As a rule, students find elementary organic chemistry a difficult course, and this, in my opinion, is largely due to lack of familiarity with straight inorganic chemistry. The chemistry of the amines, as taught in the elementary course, should be relatively simple for students familiar with the chemistry of ammonia. A knowledge of the essential differences in the behavior of the halogen in halides and the halogen in hypohalites would make simpler the action of halogens in alkaline solution on amides, and the addition reactions of hypochlorous acid. A more ready understanding of the phenomenon of hydrolysis would be of great help in appreciating the behavior of mordants, processes such as the saponification of esters, and in general the behavior of amphoteric compounds. A knowledge of the chemistry of urea really depends upon a thorough grasp of the chemistry of carbon dioxide and the existence of carbonates and carbamates. Incidentally, it may be pointed out that most students in elementary organic

courses usually regard this word as a misprint. The halides of phosphorus, phosgene, chromyl, and sulfuryl chlorides are substances which appear quite anomalous and mysterious to most students who enter an organic course after having completed a standard course in inorganic chemistry. The general behavior of acid halides, if once learned in inorganic chemistry, makes clear a considerable section of organic chemistry, where compounds of this class, organic and inorganic, are manifestly important.

As far as laboratory work is concerned, many college courses do not sufficiently recognize the experience gained in the secondary schools. This frequently results in a lack of interest and a feeling of over-confidence on the part of the student. Laboratory tendencies evident today are, first, to make the work largely like, in fact frequently a repetition of, the better secondary school laboratory exercises. The law of constant proportion, chemical equivalents, the amount of water in crystalline copper sulfate or barium chloride are expressions having to do with experiments conducted in many of the up-to-date secondary schools, yet the same experiments are found in college chemistry manuals and frequently carried out in college even by students who have already done them. A second tendency is to make the course savor too strongly of analytical chemistry, either qualitative or quantitative. It is generally believed that most students learn most of their inorganic chemistry in their college qualitative courses. With this opinion I am inclined to agree. However, freshmen, I believe, concentrate too much on getting unknowns right, on having reports accepted, or too closely rely on the table of separations, and miss the really important facts of chemistry with which they are dealing. The courses dealing with quantitative are little less than farcical unless they permit students to utilize the more delicate balances, which, because of the students' inexperience and the impossibility generally of providing adequate supervision, leads to a cultivation of lack of respect for balances and other delicate instruments. The third tendency is to elaborate physical chemistry too fully. I am in complete accord with the desire to have the students begin to think along physical chemical lines from the very outset of their careers. I do feel that most freshmen, students approximately 18 years of age, are not sufficiently mature mentally to really appreciate physical chemistry. Parrot-like, they can learn the laws presented, and may finally solve certain problems, but I have a very firm conviction that they really have little notion of just where they are going, and the important applications of their experiments are all too infrequently matters not even brought to their attention. Some one has aptly said that physical chemistry is a state of mind, and I feel that it is unjust to freshmen to expect them to have acquired or to acquire such a state to a very marked degree.

In order to teach the students inorganic chemistry, I believe that advantage should be taken of a young person's natural desire to make something. In my opinion the popularity of the extremely well-known book, "Creative Chemistry," is in no small measure due to the splendid way the creative side of this science is presented. Hence, I feel that experiments in the freshman year, certainly for those who have presented chemistry, should be of a preparative character. If an experiment requires more than one laboratory period, so much the better. This gives the individual a chance to concentrate for a considerable period of time on one important topic, and this is a great advantage over the so familiar test-tube type of experiment which students rush through in one period, usually without understanding it, and then forget. The dictionary is a good book, but not the best reading because, as has been said, the subject changes so often. Preparative experiments (we run 16 in an ordinary college year) give the students continuity of subject and do not spatter the attention over too large a section of the science in a short space of time. The preparative experiments may be so varied as to permit teaching a great deal of laboratory technic, apparatus may be simple or complicated, purifications may be carried out to any desired extent. A reasonable amount of elementary analytical work, such as testing the purity of the sample either qualitatively or quantitatively, if desired, may be introduced to give the student an idea of the paths which he will subsequently follow. By calculating the amounts of reagents necessary and the cost of the chemicals used, also theoretical and percentage yields, the student will be shown that problems are not mere mathematical exercises, seemingly thrown into a course in an otherwise attractive subject to make it tedious and difficult, but have a very real and practical use. There are available a few laboratory manuals, very few old ones and a somewhat larger number of new ones, which include preparative experiments. It is perhaps worthwhile to mention that the laboratory manuals, which accompany what I have termed "modern texts," include preparative work. Courses presenting laboratory work of the nature here recommended are already being given in a few institutions, and to my mind indicate the way the freshman course in college is developing.

Faraday Medal Awarded to Italian. The Council of the Institution of Electrical Engineers has made the eighth award of the Faraday Medal to Signor Guido Semenza of Milan. This medal is awarded by the Council of the Institution either for notable scientific or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science, without restriction as regards nationality, country, residence, or membership of the Institution.

Signor Semenza has for many years taken a leading part in the development of the applications of electricity.—*Chem. News*, **138**, 109 (Feb. 15, 1929).

CHEMISTRY AND SCIENCE IN COLLEGE ENTRANCE AND GRADUATION REQUIREMENTS[1,2]

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The purpose of this article is to show the status of chemistry and science in college entrance and college graduation requirements primarily from a quantitative standpoint and to furnish the basic matter from which the relationship of the foregoing subjects in curricula, as well as other educational implications, may be determined.

The basic data of this article were obtained in part from the catalogs of 80 publicly controlled and 102 privately controlled colleges and universities. These institutions are representative, having been selected with the approval of the United States Bureau of Education. The information thus obtained was checked through personal correspondence with the heads of the chemical departments of these institutions.

Entrance Units in Science and Chemistry

It is desired to show the relation of the required college entrance units in science and in chemistry, and the elective units in chemistry to the total number of prescribed units leading to the bachelor degrees in arts, science, education, business, commerce, agriculture, engineering, and home economics.

Public Institutions

In the table following are consolidated the entrance requirements in science and in chemistry for 80 publicly controlled institutions.

The following explanation will indicate how to interpret the data given in Table I.

Bachelor of Arts.—Of the 80 public institutions, 59 offer the bachelor of arts degree. Fifty-five of the 59 prescribe 15 entrance units and 4 require 16 units. Thirty-five, or 59.3%, of the 59 institutions do not prescribe science as a college entrance subject, the remaining 24.7% prescribe 1 or 2 units of science; only three institutions require 2 units. None of the 59 institutions prescribe chemistry as an entrance credit, but all permit it as an elective. The greatest frequency is 55 cases of 1 unit. Only 2 institutions permit less than 1 unit and 3 more than 1 unit of chemistry.

The percentage of the 80 publicly controlled institutions prescribing science for entrance according to degrees are as follows: home economics 57.5, education 54.3, commerce and business 53.3, bachelor of science 50,

[1] Taken from a coöperative study of "Chemistry and Science in College Entrance and College Graduation Requirements," made under the auspices of the United States Bureau of Education and the American University by the author.

[2] Read before the Division of Chemical Education at the 76th Meeting of the American Chemical Society, September 12, 1928, at Swampscott, Mass.

TABLE I

ENTRANCE UNITS REQUIRED

Name of degree and number of the 80 public institutions granting it	Total entrance units		Science		Chemistry		Electives in chemistry	
	Institutions	Units	Institutions	Units	Institutions	Units	Institutions	Units
Bachelor of Arts	55	15	35	0	59	0	2	0.5–1
59	4	16	1	0–1			55	1
			19	1			3	1 plus
			1	1				
			3	2				
Bachelor of Science	31	15	17	0	34	0	1	0.5–1
34	3	16	15	1			32	1
			2	2			1	1 plus
Bachelor's Degree in	42	15	21	0	46	0	2	0.5–1
Education	4	16	22	1			41	1
46			3	2			3	1 plus
Bachelor's Degree in	29	15	14	0	30	0	2	0.5–1
Business and Commerce 30	1	16	15	1			27	1
			1	2			1	1 plus
Bachelor's Degree in	2	14–15	21	0	39	0	1	0.5–1
Agriculture	36	15	16	1	1	1	34	1
40	2	16	3	2			5	1 plus
Bachelor's Degree in	1	14.5	28	0	52	0	2	0.5–1
Engineering	51	15	22	1	2	1	46	1
54	2	16	4	2			6	1 plus
Bachelor's Degree in	1	14.5	17	0	37	0	2	0.5–1
Home Economics	34	15	16	1	1	1	33	1
38	3	16	5	2			3	1 plus

engineering 48.9, agriculture 47.5, bachelor of arts 40.6. Accordingly, the percentage of institutions prescribing science for entrance to the technical curricula of agriculture and engineering is smaller than the proportion of institutions offering the less technical curricula leading to the bachelor of science degree and those of commerce and business, education and home economics.

Private Institutions

The entrance requirements in science and chemistry for the 102 privately controlled institutions are consolidated in the following table.

The following explanation will indicate how to interpret the data given in Table II.

Bachelor of Arts.—Of the 102 private institutions 96 offer this degree. Eighty-six of the 96 institutions require a total of 15 entrance credits, 1 requires 14, 4 require 14.5, 1 requires 15 or 16, and 4 require 16 credits. Sixty-eight, or 70.8%, of the 96 institutions do not require science as an entrance subject. Of the 28 cases, or 29.2%, requiring science as an

TABLE II

ENTRANCE UNITS REQUIRED

Name of degree and number of the 102 private institutions granting it	Total entrance units		Science		Chemistry		Electives in chemistry	
	Institutions	Units	Institutions	Units	Institutions	Units	Institutions	Units
	1	14	66	0	95	0	95	1
Bachelor of Arts	4	14.5	1	0.5–3	1	1*	3	1–2
96	86	15	25	1				
	1	15–16	2	2				
	4	16						
Bachelor of Science	4	14.5	25	0	44	0	40	1
44	38	15	13	1			4	1–2
	2	16	1	2				
Bachelor's Degree in	12	15	6	0	13	0	13	1
Education	1	15–16	7	1				
13								
Bachelor's Degree in	1	14	11	0	15	0	15	1
Business and Com-	13	15	3	1				
merce	1	15–16	1	2				
15								
Bachelor's Degree in	1	14.5	15	0	30	0	31	1
Engineering	30	15	13	1	2	1	1	2
32	1	15–16	4	2				
Bachelor's Degree in	6	15	3	0	6	0	6	1
Home Economics			2	1				
6			1	2				

* Physics or Chemistry

entrance credit, 1 requires $^1/_2$ to 3 units, 25 require 1 unit, and 2 require 2 units. None of the 96 institutions prescribe chemistry for college entrance, but 1 institution recognizes an alternate of 1 unit between chemistry and physics. Chemistry is permitted as an elective subject by all of the 96 institutions, 93 of which allow 1 unit and the remaining three allow 1 or 2 units.

The percentage of the 102 privately controlled institutions prescribing science for entrance according to degrees are as follows: education 53.8, engineering 53.1, home economics 50, bachelor of science 43.1, bachelor of arts 28.7, business and commerce 26.6. Accordingly, the percentage of institutions prescribing science for entrance to the technical curricula of engineering is greater than that for those prescribing it for entrance to the less technical curricula leading to degrees in business and commerce, bachelor of arts, bachelor of science, and home economics. The percentage is approximately the same as it is for the curricula in education, namely, 53.8%.

General Conclusions

As to the proportion of institutions studied prescribing science for each degree, a comparison shows that with the exception of the curricula in engineering the public exceed the private institutions as follows: edu-

cation 0.5%, bachelor of science 6.9%, home economics 7.5%, bachelor of arts 11.3%, and business 26.7%. With respect to the engineering curricula, the private exceed the public institutions by 5%.

As chemistry is an elective in all cases where science is prescribed, the relation of chemistry to the several curricula is analogous to that of science.

The outstanding fact in college entrance requirements for both the publicly and privately controlled institutions under consideration is that from one-half to more than two-thirds of these institutions do not require any entrance credits in science, including chemistry.

In the remaining institutions that do require an entrance credit in science, including chemistry, no preference for any branch of science is shown. Only four institutions prescribe chemistry as a college entrance subject.

The question may therefore be raised: does not this lack of preference lead to the conclusion that the universities and colleges that require entrance credit in science, including chemistry, are more concerned that general scientific notions and methods should be emphasized rather than knowledge of any particular scientific subject from the standpoint of fundamental principles?

Chemistry and Science in College Graduation Requirements

It is desired to show the required number of semester hour credits in chemistry and in science, including chemistry, in relation to the total number of prescribed graduation credits for the curricula leading to the following degrees: Bachelor of Arts; special Bachelor of Arts; Bachelor of Science; special Bachelor of Science; the bachelor's degree in commerce and business, in education, in agriculture, in special agriculture, in home economics, in civil, mechanical, and electrical engineering, in special engineering, in chemistry, in special curricula in chemistry, and in chemical engineering.

It is quite as important in chemical education to get an insight into the emphasis placed on science and chemistry in all curricula as well as those in chemistry and chemical engineering.

The outstanding frequencies in science, including chemistry, and in chemistry in semester hour credits for the curricula listed in Table III follow. When more than one frequency is indicated, the highest frequency appears first.

Chemical Engineering—Science 61 to 70 and 71 to 80; Chemistry 51 to 60 and 41 to 50.
Chemistry—Science 61 to 70, 51 to 60, and 71 to 80; Chemistry 41 to 50, 31 to 40, and 51 to 60.
Special Chemistry—Science 61 to 70 and 41 to 50; Chemistry 31 to 40, 41 to 50, and 51 to 60.
Metallurgy and Mining Engineering—Science 51 to 60, 61 to 70, and 31 to 40; Chemistry 10 to 20 and 21 to 30.

TABLE III

THE MINIMUM, MEDIAN, AND MAXIMUM SEMESTER HOUR CREDITS REQUIRED FOR GRADUATION, AND THOSE PRESCRIBED FOR SCIENCE, INCLUDING CHEMISTRY, AND IN CHEMISTRY FOR THE SEVERAL CURRICULA IN 80 PUBLIC INSTITUTIONS

Name of curriculum	Graduation requirements: Graduation			Science			Chemistry		
	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.
Chemical Engineering	125	146	181.5	40	60.7	95	12	52.7	75
Chemistry	120	131.5	186	36	65	98.7	24	44.6	84
Special Chemistry	120	141	201	16	51	84	6	36	69
Metallurgy and Mining Engineering	126	144	195.9	15	54	130	9	22	67
Special Agriculture	120	131	195	0	39	80	0	14	40.5
Home Economics	120	130	189	0	27.3	60	0	13.3	30
Agriculture	120	139	176	8	32	65	6.7	14	23.3
Special Engineering	124	142	193	6	22	84	0	9.5	78.1
Special Bachelor of Science	120	134	195.5	0	28	127	0	8	66
Civil, Electrical, Mechanical Engineering	120	144	193.6	11	22	43	5	10	20
Education	117.3	129.5	183	0	13	60	0	3	34
Bachelor of Science	120	125	160	0	27	74	0	0	10
Special Bachelor of Arts	120	125	162	0	7.3	58	0	0	37
Commerce and Business	120	126	168	0	10	46	0	0	20
Bachelor of Arts	120	126	186	0	10	66	0	0	8

TABLE IV

THE MINIMUM, MEDIAN, AND MAXIMUM SEMESTER HOUR CREDITS REQUIRED FOR GRADUATION AND THOSE PRESCRIBED FOR SCIENCE, INCLUDING CHEMISTRY, AND CHEMISTRY FOR THE SEVERAL CURRICULA IN 99* PRIVATE INSTITUTIONS

Name of curriculum	Graduation requirements: Total graduation			Science			Chemistry		
	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.
Chemical Engineering	120	146	200	42	73	104	30	59	86
Chemistry	120	132	196.5	36	71	126	24	54	94
Metallurgy and Mining Engineering	120	145	196.8	16.6	44	109	8	20	91
Home Economics	120	120	161	12	29.7	68	6	13	22
Special Bachelor of Science	106.7	130	208	0	24	108	0	10	50
Civil, Electrical, Mechanical Engineering	120	149	218.7	12	24	70	6	10	20
Education	105	126	188	0	12	60	0	0	23.3
Bachelor of Science	120	128	169	6	18	60	0	0	24
Special Bachelor of Arts	120	124	148	0	11	68	0	4	48
Commerce and Business	120	126	180	0	8	43	0	0	21

* Three of the 102 institutions are not included because of difficulty in reducing data to semester hour credits.

Special Agriculture—Science 31 to 40 and 41 to 50; Chemistry 11 to 15.
Home Economics—Science 21 to 30, 31 to 40; Chemistry 11 to 20.
Agriculture—Science 21 to 30 and 31 to 40; Chemistry 11 to 20 and 6 to 10.
Special Engineering—Science 11 to 20 and 21 to 30; Chemistry 5 to 10.
Special Bachelor of Science—Science 11 to 20, 21 to 30, 51 to 60, and 1 to 10; Chemistry 0, 3 to 10, and 11 to 20.
Civil, Electrical, and Mechanical Engineering—Science 21 to 30, 10 to 20; Chemistry 7 to 8 and 9 to 10.
Education—Science 2 to 10 and 11 to 20; Chemistry 0, 3 to 10, and 11 to 20.
Bachelor of Science—Science 11 to 20, 5 to 10, or 51 to 60; Chemistry 0.
Special Bachelor of Arts—Science 4 to 10, 0, and 11 to 20; Chemistry 0.
Commerce and Business—Science 1 to 10, 11 to 20, and 0; Chemistry 0.
Bachelor of Arts—Science 4 to 10 and 11 to 20; Chemistry 0.

The outstanding frequencies in science, including chemistry, and in chemistry in semester hour credits for the curricula listed in Table IV are as follows. When more than one frequency is indicated the highest frequency appears first.

Chemical Engineering—Science is uniformly distributed between 40 and 104 semester hour credits with a slight emphasis on 71 to 80 and 91 to 100; the same uniformity of distribution is true of chemistry between 30 and 86 with slight emphasis on 30 to 40 and 51 to 60.
Chemistry—Science 61 to 70, 81 to 90, and 41 to 50; Chemistry 20 to 40, 41 to 50, and 71 to 80.
Metallurgy and Mining Engineering—Science 51 to 60, 30 to 40, or 16 to 20; Chemistry 13 to 20, 21 to 30, and 8.
Home Economics—Science 21 to 30, and 31 to 40; Chemistry 11 to 20 and 6 to 10.
Special Bachelor of Science—Science 11 to 20, 21 to 30, and 1 to 10; Chemistry 0, 3.3 to 10, 21 to 30, and 11 to 20.
Civil, Electrical, Mechanical Engineering—Science 21 to 30, and 14 to 20; Chemistry 6 to 10.
Education—Science 10, Chemistry 0.
Bachelor of Science—Science 11 to 20 and 1 to 10; Chemistry 0.
Special Bachelor of Arts—Science 6 to 10; Chemistry 0, and 4 to 10.
Commerce and Business—Science 0; Chemistry 0.
Bachelor of Arts—Science 3 to 10 and 11 to 20; Chemistry 0.

For purposes of comparison the following consolidated table shows the average requirements of semester hour credits for graduation, science including chemistry, and chemistry for both the public and the private institutions under consideration.

Table V is arranged so as to list in descending order the highest requirements in chemistry in public institutions.

Attention should be called to the fact that the private institutions do not offer degree courses in agriculture, nor are highly specialized courses in engineering found to the extent that they are in public institutions.

In this discussion based on Table V, the various degrees or curricula are classified according to the following groups:

TABLE V

AVERAGE TOTAL SEMESTER HOUR CREDITS REQUIRED FOR GRADUATION, AND THOSE PRESCRIBED FOR SCIENCE, INCLUDING CHEMISTRY, AND CHEMISTRY FOR THE SEVERAL CURRICULA FOR BOTH PUBLIC AND PRIVATE INSTITUTIONS

Name of curriculum	Number of cases		Average requirement of semester hour credits					
			Total for graduation		Science**		Chemistry**	
	Public	Private*	Public	Private	Public	Private	Public	Private
					Group I			
Chemical Engineering	42 (48)	24 (24)	141	147	69.1	72.8	52.3	58.3
Chemistry	33 (39)	28 (30)	136.4	140	65.4	82.5	47.2	60.6
Special Chemistry	15 (16)	..	143.6	...	54.8	..	38.7	..
					Group II			
Metallurgy and Mining Engineering	20 (44)	10 (20)	146	129.8	53.4	45.3	25.7	25.8
Special Agriculture	21 (193)	..	146.8	...	37.2 (1)	..	15.6 (2)	..
Home Economics	46 (95)	9 (17)	132.5	134.3	26.5 (1)	31.8	13.6 (5)	14.1
Agriculture	36 (37)	..	135.4	...	34.1	..	12	..
Special Engineering	40 (80)	..	129.4	...	26.5	..	11.8 (4)	..
Special Bachelor of Science	53 (196)	28 (73)	134.2	138.1	33.1 (17)	35.1 (4)	10.5 (69)	12.6 (28)
Civil, Mechanical, and Electrical Engineering	56 (161)	31 (80)	144.2	150.9	22.2	25	9.2	10.1
					Group III			
Education	67 (168)	20 (40)	135.7	128.5	16.8 (20)	15.6 (6)	5.7 (83)	5 (26)
Bachelor of Science	30 (30)	34 (35)	129.7	138.5	26.9 (3)	20.8	2 (22)	3.8 (22)
Special Bachelor of Arts	26 (112)	21 (44)	119.9	124.2	11.6 (32)	22 (5)	1.8 (98)	7.7 (23)
Commerce and Business	38 (123)	16 (24)	132.4	134	10.7 (21)	9.5 (8)	1.2 (105)	3.4 (17)
Bachelor of Arts	56 (60)	88 (99)	124.9	125.4	10.9 (9)	10.5 (9)	0.28 (57)	1.5 (89)

* Figures within the parentheses indicate the number of cases of the respective degree.

** Figures within parentheses indicate the number of cases requiring neither science nor chemistry.

I. *Those in which chemistry is basic:* chemical engineering; chemistry, including special chemistry curricula.

II. *Those in which chemistry is necessary to the proper study of other subjects:* agriculture, including special agriculture; home economics; engineering, including special engineering; metallurgy and mining; and special bachelor of science.

III. *Those in which chemistry may be selected largely for "cultural training:"* bachelor of arts, including special bachelor of arts; bachelor of science; education; commerce and business. Consideration is given to science in relation to each of these groups.

Group I. *Science requirements.*—In the first group the highest average requirement in science is found in the curricula for chemistry in private institutions with an average of 82.5 credits; the lowest requirement in science is found for the curricula in special chemistry in public institutions with an average requirement of 54.8 credits.

In the private institutions, the science requirement in chemical curricula slightly exceeds that of science in chemical engineering curricula; but in public institutions the science requirement for chemical engineering curricula slightly exceeds the requirement for science in chemical curricula.

It is noted that the average science requirements for all the curricula in this group except for special chemstry for which no data are given are greater for private institutions than for the public.

Chemistry requirements.—For chemistry the highest average is 60.6 credits found in the curricula for chemistry in private institutions. This slightly exceeds the chemistry requirement for chemical engineering curricula in private institutions.

The average chemistry requirement in chemical engineering for the public institutions is 52.3 credits. This is slightly higher than for chemical curricula in public institutions.

The lowest requirement for chemistry in this group is found in the curricula for special chemistry in public institutions.

The average requirements in chemistry are greater for the private institutions than for the public.

In those curricula in which chemistry is studied largely for its own sake, the amount of science prescribed varies from more than one-third to nearly two-thirds of the total degree requirements, and the amount of chemistry prescribed varies from more than one-fourth to nearly one-half.

Group II. *Science requirements.*—In the second group the highest average requirement for science is in the curricula for special agriculture in the public institutions with 37.2 credits; the second highest requirement for science is found in the curricula in general agriculture with 34.1 credits; the lowest being found in the curricula in engineering in the public institutions with 22.2 credits.

It also should be noted that the science and the chemistry requirements

for special agriculture and special engineering both are higher than for regular curricula in engineering and agriculture.

Chemistry requirements.—In the public and private institutions the highest requirement made for chemistry is in the curriculum for metallurgy and mining: the public require 25.8 credits, and the private 25.7. Special agriculture ranks second, with 15.6 credits; and home economics third, with 14.1 credits.

In those curricula in which chemistry is an essential factor in the development of other scientific subjects the amount of science varies from approximately one-sixth to one-third of the total degree requirements and the amount of chemistry prescribed varies from one-fifteenth to one-fifth.

Group III. *Science requirements.*—In the third group the highest average requirement in science is found in the bachelor of science curricula in public institutions with an average of 26.9 credits; the lowest requirement in science is found in the curricula for commerce and business in private institutions with an average of 9.5 credits.

The science requirement in the special bachelor of arts curricula, in private institutions with an average of 22 credits, ranks second highest of all the science credit requirements in this group of degree curricula and, furthermore, slightly exceeds that of the bachelor of science in private institutions. It is also nearly twice as great as those of the special bachelor of arts curricula in public institutions.

In the public institutions the average science credits required in the bachelor of science curricula is over twice as great as that of the spcieal bachelor of arts curricula.

Chemistry requirements.—The highest average credit requirement in chemistry in all the degree curricula in this group is in the special bachelor of arts curricula in private institutions with 7.7 credits. This is twice as great as that for the bachelor of science curricula in private institutions, and nearly four times as great as the average credit requirement in either the bachelor of science curricula or the special bachelor of arts curricula in public institutions.

The lowest average requirement in chemistry is found in the commerce and business curricula in public institutions.

It is further noted that with the exceptions of the education and bachelor of arts curricula the average credits required in chemistry in the private institutions exceed those in the public institutions.

In those curricula in which chemistry is primarily cultural the amount of science required varies from one-fourteenth to one-fifth of the total degree requirement; and the amount of chemistry prescribed varies approximately from zero to one-sixteenth.

Attention is called to the fact that the majors in science or in chemistry taken in connection with the bachelor of arts or bachelor of science degrees

are not included in the foregoing average requirements. They may equal or exceed the highest average heretofore mentioned.

Majors, Minors, and Related Minors for the Bachelor of Arts and Bachelor of Science Degrees

In the following table the minimum, median, and maximum semester hour credits for the major, minor, and related minor required in the 80 publicly and 99 privately controlled institutions for the bachelor of arts and bachelor of science degrees are given.

TABLE VI

	Major			Minor			Related minor		
	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.
Public									
Bachelor of Arts	16	24	40	0	0	20	0	0	18
Bachelor of Science	9	20	36	0	0	30	0	0	20
Private									
Bachelor of Arts	9	24	40	0	0	20	0	0	28
Bachelor of Science	15	24	75	0	0	20	0	3	20

The outstanding frequencies in the major chemistry for the bachelor of arts and bachelor of science degrees are as follows. When more than one frequency is indicated, the highest frequency appears first.

Bachelor of Arts in the Public Institutions Listed. Major; 13 cases of 24 credits, 10 of 18, and 7 of 20. Minor; 23 cases of 0 credits, 9 of 12, and 4 each of 18 or 20 credits. Related minor; 33 cases of 0 credits, 6 of 12, and 3 of 18.

Bachelor of Science in the Public Institutions Listed. Major; 4 cases of 18, 20, and 30 credits, and 3 cases of 24 credits. Minor; 15 cases of 0 credits, 3 of 12, and 2 of 20. Related minor; 15 cases of 0 credits, and 2 cases each of 18 and 20 credits.

Bachelor of Arts in the Private Institutions. Major; 20 cases of 24 credits, 18 cases of 18, and 12 of 30 credits. Minor; 40 cases of 0 credits, 13 of 12, 5 of 18, and 2 each of 15 and 16. Related minor; 52 cases of 0 credits, 3 cases each of 6 and 13, and 2 cases each of 14 and 20 credits.

Bachelor of Science in the Private Institutions Listed. Major; 9 cases of 24 credits, 7 of 18, and 4 of 30 credits. Minor; 18 cases of 0 credits, 4 cases of 12 credits, and 2 of 19 and 18. Related minor; 15 cases of 0 credits, 6 of 12, and 2 cases each of 6, 18, and 20 credits.

According to Table VII, in the 48 public institutions the six subjects that are given the greatest recognition in the major in chemistry, in order, are organic, qualitative, quantitative, physical, general, and inorganic chemistry; in the minor in chemistry they are organic, general, qualitative, quantitative, physics, and inorganic chemistry; and in the related minor in chemistry they are organic chemistry, physics, general chemistry, qualitative, physical, and inorganic chemistry.

Attention is called to the number of literary and non-chemistry subjects included in the majors, minors, and related minors.

TABLE VII

THE PERCENTAGE OF 48 PUBLICLY CONTROLLED INSTITUTIONS AND 69 PRIVATELY CONTROLLED INSTITUTIONS THAT INCLUDE CERTAIN COURSES IN CHEMISTRY AND IN OTHER SUBJECTS IN THE MAJOR, MINOR, AND RELATED MINOR IN CHEMISTRY

Subject	Major		Minor		Related minor	
	Public	Private	Public	Private	Public	Private
Organic Chemistry	81.3	89.9	47.9	44.9	16.6	24.6
Qualitative Chemistry	75	85.5	29.2	40.5	8.3	15.2
Quantitative Chemistry	75	81.1	22.9	27.1	6.3	14.4
Physical Chemistry	64.1	75.4	8.3	7.4	6.3	5.8
General Chemistry	54.2	78.3	41.6	40.6	12.5	27.5
Inorganic Chemistry	25	24.6	12.5	7.4	6.3	1.9
Physiological Chemistry	12.5	1.4	6.3	..	..	..
Analytical Chemistry	10.4	7.8	10.4	2.9	4	..
Industrial Chemistry	10.4	7.2	..	1.4	..	1.4
Foreign Language	8.3	..	2	..	4	..
Bacteriology	8.3	..	4	..	..	1.4
Physics	6.3	14.5	20.8	26.1	14.5	15.9
Advanced Inorganic Chemistry	6.3	5.8	..	2.9	..	..
History of Chemistry	6.3	..	2	1.4	..	..
Electrochemistry	6.3	..	..	..	..	..
Chemical Microscopy	4	..	..	1.4	..	..
Chemical Engineering	4	..	..	..	..	..
Technical Analyses	4	..	..	..	..	..
Mathematics	2	10.1	14.5	17.4	12.5	14.5
English	2	..	..	..	..	..
Geology	2	2.9	4	2.9	6.5	7.2
Food Chemistry	2	2.8	..	..	2	..
Advanced General Chemistry	2	..	..	..	..	..
Advanced Organic Chemistry	2	..	..	..	..	..
Advanced Physical Chemistry	2	2.9	..	..	..	..
Biology	2	1.4	6.3	8.7	4	8.7
Metallurgy	2	..	..	1.4	..	..
Thesis	2	..	..	..	..	..
Zoölogy	..	..	4	..	..	1.4
Microbiology	..	..	..	..	2	..
Literature	..	..	2	..	..	..
History	..	..	2	..	..	1.4
Philosophy	..	..	2	..	..	..
Economics	..	..	2	..	2	..
Public Speaking	..	..	2	..	..	..
Education	..	..	..	..	2	..
Mineralogy	..	..	..	1.4	2	1.4
Electricity	..	..	..	1.4	..	1.4
Astronomy	..	..	..	..	..	1.4
Organic Analyses	..	..	..	..	..	1.4
Fuel Analyses	..	..	..	1.4	..	..
Water Analyses	..	..	..	1.4	..	..
Micro-Chemistry	..	..	..	1.4	..	..
Mechanics	..	..	..	1.4	..	..
Teaching Chemistry	..	..	..	1.4	..	..
Mineralogy	..	..	..	1.4	..	1.4
Engineering	..	..	..	1.4	..	..

In the 69 private institutions the six subjects that are given the greatest recognition in the major in chemistry, in order, are the same as in the public institutions with the exception that general chemistry has greater recognition than physical; in the minor in chemistry the recognition is the same; in the related minor in chemistry they are, in order, organic, qualitative, quantitative, physics, mathematics, and biology.

Attention is called to the tendency to include scientific subjects in the majors, minors, and related minors in the private institutions as distinguished from the tendency to recognize literary subjects in the public institutions.

Classroom and Laboratory Requirements

From tables too lengthy to publish showing the frequencies of combinations of classroom and laboratory requirements in chemistry in 64 public and 82 private institutions for nine different courses which are most often prescribed in chemistry the following conclusions are made.

Less than one-fifth of all the 64 publicly supported institutions under consideration have the same number of classroom and laboratory hours per week in general chemistry, qualitative, and quantitative; for organic, less than one-seventh of the institutions follow the same practice; for physical, one-tenth; and in technical, agricultural, chemical engineering, and industrial chemistry, the number of institutions following any specific weekly classroom- and laboratory-hour plan are too few to mention.

Less than one-fifth of the 82 privately controlled institutions under consideration follow the same weekly classroom- and laboratory-hour plan for general chemistry, qualitative and physical chemistry; one-seventh in quantitative and organic; one-tenth in industrial; and in the remaining curricula there is no common practice.

The outstanding fact is that in both the public and the private institutions under consideration, one-fifth follow a common practice with respect to weekly classroom and laboratory hours in three or four specific courses in chemistry and in all other courses in chemistry there is no approach to any standard practice.

This great lack of uniformity points to the need of not only a scientific study of the different plans in combining classroom and laboratory instruction, but also of the importance of the different methods of teaching the several branches of chemistry.

General Summary

In addition to observations and conclusions made heretofore on the preceding tables, the following general conclusions are made as to the recognition of science and chemistry in the fields of secondary and higher education.

1. An unusual opportunity exists for a more general recognition of science as a basic subject in secondary education.

2. In view of the lack of a definite recognition of chemistry as a college entrance subject and in view of the efforts on the part of a great many colleges to bridge high-school chemistry over to college chemistry, a great opportunity exists for a more extended recognition of chemistry as a college entrance subject and an improvement of its teaching in the high schools.

3. Science and chemistry have become essential requirements in the majority of college curricula.

4. Science and chemistry are greatly ramified throughout the many fields of higher education, and in each of these fields there is a great diversity of units required especially with respect to chemistry.

5. In curricula in which science or chemistry is studied for its own sake it appears that there may be danger of excessive recognition of specific sciences or chemistry at the expense of broader humanistic studies which are vital to education and life.

6. In curricula where chemistry is fundamental to other subject matter there is danger that the appreciation of fundamental principles may be lost in the zeal for applications.

7. In cultural curricula leading to the bachelor's degree there is danger of the student failing to obtain the scientific viewpoint because of a more intense interest in humanistic studies.

Coöperative Scientific Survey of Secondary Research. A scientific survey of secondary education in England and the United States has been initiated by the Division of Secondary Education of the University of Pennsylvania with the coöperation of committees in both countries. The English committee, of which Dr. Cyril Norwood (Harrow) is chairman and Mr. C. W. Bailey (Holt School, Liverpool), secretary, met on March 9th, and in the light of information given by Prof. E. D. Grizzell, of Pennsylvania, who is spending the year in England and has already accomplished much preliminary work, approved a scheme based on the selection of some fifty representative schools. Many of the problems confronting secondary education today are common to both countries, and this joint inquiry should prove helpful. The rapid growth since the war in the numbers of schools and pupils has been accompanied by the creation of new types of school and modifications of the old to meet changed conditions, and there has been an enormous amount of research and experimentation in this field, of which the joint survey will doubtless take cognizance. Of special interest at the present time are the numerous important researches recently conducted under the auspices of the Iowa Research Conference on Commercial Education, the survey of secondary commercial education in Minnesota and other studies described in the report for 1927–28 of the United States Commissioner of Education, designed to contribute to improvement of instruction in commercial departments of secondary, normal, and collegiate schools.— *Nature* (London), **123,** 476 (Mch. 23, 1929).

SCHOLARSHIP AND EMPLOYMENT RECORD OF EVENING STUDENTS*

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This paper gives the results of a study which was made of the scholarship in evening classes, and the employment during the day, of young men taking courses in chemistry and chemical engineering at the Polytechnic Institute of Brooklyn in the evening. These courses are of standard college grade and are taken for the purpose of fitting the students for professional work as chemists or chemical engineers.

The study was a natural corollary of an investigation carried out in 1925–26 by a committee of the faculty of Polytechnic at the request of the "Society for the Promotion of Engineering Education" on Coöperative Engineering Education.[1] As the Evening Session of the Polytechnic provides instruction for men employed during the day, some in technical positions and some in positions which may be termed non-technical, it was thought that a study of their scholastic and employment records might throw some light on the educational advantages of technical employment for the student of engineering and chemistry.

Method of Study

Records were available of the grades given to these young men during the entire period of attendance at the Polytechnic Institute. No attempt was made to include scholastic records obtained elsewhere. At the Polytechnic Institute *A* indicates the highest standing. This grade is not generally given to more than 10% of the class. *B* indicates more than average achievement and *C* fair to average achievement. This grade is given to a large percentage of the class. *D* indicates failure to pass, with the permission to take a reëxamination after suitable preparation. A large proportion of those receiving a *D* grade take the subject over again. The grade *E* is given for such a bad failure that the subject must in every case be repeated.

All of the grades of each student were tabulated and the students divided into groups of *A*, *B*, *C*, and *D* students by the following method:

An *A* student is one who has a majority of *A*'s.

A *B* student is one who has a majority of *A*'s and *B*'s.

A *C* student has a majority of *C*'s.

A *D* student is one who receives a grade of *D* or *E* in most of his subjects and who is obviously failing in his scholastic work.

* Read before the Division of Chemical Education at the 76th Meeting of the American Chemical Society, September 12, 1928, at Swampscott, Mass.

[1] *Bull.* No. 12 of the Investigation of Engineering Education, S. P. E. E., May, 1927.

Information as to age, years employed, salary, and character of employment was obtained by means of a questionnaire which the students were asked to fill out. Salary was given either in the actual amount received or by means of letters with the following indication:

Below $25.00 per week	*D*
$25.00–$34.00 per week	*C*
$35.00–$45.00 per week	*B*
More than $45.00 per week	*A*

Under "character of employment," "technical" indicates that a man is working in some capacity as a chemist, generally in a laboratory, although some of the young men were employed in plant work involving chemical processes.

The evening courses at the Polytechnic Institute, as carried on, parallel the day courses as to content of the course and proficiency acquired by the students receiving the same grade. Full credit is given to evening students who transfer to the day courses for courses passed in the evening classes. Such transfers are often made. The actual time devoted to instruction in the evening in a given subject is generally somewhat less than that assigned to the equivalent day course. This is feasible because the evening student generally makes more rapid progress in a given time than the day student, probably on account of being older, more mature, and putting forth greater effort. Evening courses are generally given by the same professors and instructors who give the equivalent day courses.

In general, the evening student takes only half as many courses in a year as the day student on account of the limited amount of time and therefore a four-year day course generally requires eight years for its completion in the evening.

For convenience of study and comparison, the results of this study have been tabulated, resulting in thirty tables. We first prepared tables using the actual number of students found in each category. These absolute tables are given under Roman numerals from I to XXX. We then calculated the percentage of students in each category and have these percentage figures in a column parallel with that giving the number of students. In each case two tabulations have been made. For instance, tabulation has been made for age against salary and salary against age.

Summary of All Data

While the total number of students for whom data was secured was 171, all of the desired information was not obtained for all of the group as will be noted from the following tables:

	Scholarship					*Years at Polytechnic*			
	A	*B*	*C*	*D*	No grade	1	2	3–4	Over 4
Total no.	10	52	78	22	9	71	27	23	41
Per cent	5.8	30.4	45.6	12.8	5.2	43.8	16.7	14.2	25.4

	Years Employed					*Salary*			
	1	3	5	7	+7	*A*	*B*	*C*	*D*
Total no.	6	14	25	19	26	21	16	25	16
Per cent	6.7	15.5	27.8	21.1	28.9	27.0	20.4	33.3	19.3

	Age					*Character of Employment*	
	−20	21–22	23–25	26–30	+30	Technical	Non-technical
Total no.	22	26	40	54	18	67	30
Per cent	13.7	16.3	25.0	33.8	11.2	62.6	37.4

From these data it would seem that the mortality among evening students is higher than that of day students. So far as grades show, their scholastic work is about normal. They are older than the average undergraduates and a majority are in technical employment. Almost half are earning $35.00 per week or over.

Tabulation of Data and Discussion of Results

SCHOLARSHIP VS. YEARS AT POLYTECHNIC

TABLE I

Years at Polytechnic

Scholarship	1		2		3–4		Over 4	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
A	6	60			3	30	1	10
B	16	30.8	9	17.3	7	13.5	20	38.4
C	34	43.6	13	16.7	11	14	20	25.6
D	15	68.2	5	22.7	2	9		

TABLE II

Scholarship

Years at Polytechnic	*A*		*B*		*C*		*D*	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1	6	8.4	16	22.5	34	47.9	15	21.1
2			9	33.3	13	48.1	5	18.5
3–4	3	13	7	30.4	11	47.8	2	8.7
over 4	1	2.4	20	48.8	20	48.8		

A study of II shows a steady decline in the percentage of *D* grades and a corresponding increase in *B* and *A* grades with increasing number of years' attendance at Polytechnic. This probably results in part from the tendency of poorer students to drop out, leaving a larger percentage of successful students to make up the long-term group. It is experienced, however, in many individual cases that students do show a decided mi-

provement in ability with increasing number of years spent at Polytechnic. The proportion of *C*'s remains constant.

SCHOLARSHIP VS. YEARS EMPLOYED

TABLE III

Years Employed

Scholarship	1 No.	1 Per cent	2–3 No.	2–3 Per cent	3–5 No.	3–5 Per cent	6–7 No.	6–7 Per cent	Over 7 No.	Over 7 Per cent
A			1	16.7	3	50			2	33.3
B	2	6.7	3	10	7	23.3	8	26.7	10	33.3
C	3	7	6	14	14	32.6	8	18.6	12	27.8
D			4	40	1	10	3	30	2	20

TABLE IV

Scholarship

Years employed	*A* No.	*A* Per cent	*B* No.	*B* Per cent	*C* No.	*C* Per cent	*D* No.	*D* Per cent
1			2	40	3	60		
2–3	1	7.1	3	21.3	6	42.8	4	28.6
3–5	3	12	7	28	14	56	1	4
6–7			8	42.1	8	42.1	3	15.8
Over 7	2	7.7	10	38.4	12	46.1	2	7.7

Table IV shows very little correlation between the number of years employed and scholarship. There seems to be a slight tendency to better scholarship with increasing number of years employed. The same general tendency is shown by Table III.

SCHOLARSHIP VS. SALARY

TABLE V

Salary

Scholarship	*A* No.	*A* Per cent	*B* No.	*B* Per cent	*C* No.	*C* Per cent	*D* No.	*D* Per cent
A	1	20			2	40	2	40
B	10	40	7	28	5	20	3	12
C	7	17	6	14.6	14	34.2	14	34.2
D	3	37.5	1	12.5	3	37.5	1	12.5

TABLE VI

Scholarship

Salary	*A* No.	*A* Per cent	*B* No.	*B* Per cent	*C* No.	*C* Per cent	*D* No.	*D* Per cent
A	1	4.8	10	47.6	7	33.3	3	14.3
B			7	50	6	42.9	1	7.1
C	2	8.3	5	20.8	14	58.3	3	12.5
D	2	10	3	15	14	70	1	5

Table VI showed a very marked correlation between salary and scholarship, 70.8% and 75% of the men receiving *C* and *D* salaries receive *C* and *D* grades in scholarship while only 49.9% of the *B* salary men and 47.6% of the *A* salary men receive *C* and *D* scholarship grades. It would appear from this that in giving the scholarship grades the same factors were taken into consideration as those which determine the salary grade. This is not always true of college scholarship grades.

Table V would seem to show that the *A* scholarship men do not receive as high wages as the *B* scholarship men who seem to receive the highest salaries, 68% receiving *A* or *B* salaries. The *C* scholarship men receive low salaries, only 31.6% receiving *A* and *B* salaries, while 50% of the *D* scholars receive *A* and *B* salaries.

SCHOLARSHIP VS. AGE

TABLE VII

Age

Scholarship	+30		25–30		22–24		20–21		−20	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
A	1	10	4	40	2	20	1	10	2	20
B	8	17	18	38	9	19	6	13	6	13
C	7	9.8	22	31	23	32.4	10	14	9	12.7
D	2	9	4	19	8	38	4	19	3	14.3

TABLE VIII

Scholarship

Age	*A*		*B*		*C*		*D*	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
−20	2	10	6	30	9	45	3	15
20–21	1	4.5	6	27.3	11	50	4	18.2
22–24	2	4.8	9	21.4	23	54.8	8	19
25–30	4	8.3	18	37.5	22	45.8	4	8.3
+30	1	5.5	8	44.4	7	38.9	2	11.1

From Table VIII it appears that the group of 22–24 years are the poorest students, only 26.2% receiving *A* or *B* grades, the largest percentage of *C*'s and *D*'s being found in this group. Improvement is noticed with the younger men, while the oldest group above 30 shows the best scholarship, 49.9% having received *A* or *B* grades.

This comparison is made with scholarship and two groups, one of which is engaged in technical, the other in non-technical employment. Table X shows that the group which is technically employed maintains a decidedly higher scholarship, 42.8% of this group against 32.4% of the other group receiving *A* or *B* grades. Table IX does not show this relation because of the inequality of the number of the two groups.

SCHOLARSHIP VS. CHARACTER OF EMPLOYMENT

TABLE IX

Character of Employment

Scholarship	Technical		Non-technical	
	No.	Per cent	No.	Per cent
A	4	66.7	2	33.3
B	23	74.0	8	26
C	29	63.0	17	37.0
D	7	63.6	4	36.4

TABLE X

Scholarship

Char. of em.	*A*		*B*		*C*		*D*	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Tech.	4	6.3	23	36.5	29	46	7	11.1
Non-tech.	2	6.4	8	25.8	17	54.8	4	12.9

Table XI shows that the evening students at Polytechnic have in many cases been employed a good many years before coming to the Polytechnic. For instance, 84.2% of those who have spent one year at Polytechnic have been employed more than one year, the periods ranging from two to seven

YEARS AT POLYTECHNIC VS. YEARS EMPLOYED

TABLE XI

Years Employed

Years at Poly.	1		2–3		3–5		6–7		Over 7	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1	6	15.8	7	18.4	9	23.7	7	18.4	9	23.7
2	1	7.1	4	28.6	5	35.7	2	14.3	2	14.3
3–4	0		2	10	10	50	3	15	5	25
over 4	0		1	4.4	5	21.7	6	26	11	47.9

TABLE XII

Years at Polytechnic

Years employed	1		2		3–4		Over 4	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1	6	85.7	1	14.3	0		0	
2–3	7	50	4	28.6	2	14.3	1	7
3–5	9	31	5	17.3	10	34.4	5	17.3
6–7	7	38.8	2	11.1	3	16.7	6	33.3
over 7	9	33.3	2	7.4	5	18.5	11	40.7

years. The other groups show similar conditions. This does not necessarily mean that these young men worked as long as this before seeking more education. Many of the evening students at Polytechnic have taken evening courses at other evening schools in the metropolitan area.

YEARS AT POLYTECHNIC VS. SALARY

TABLE XIII

Salary

Years at Poly.	*A* No.	*A* Per cent	*B* No.	*B* Per cent	*C* No.	*C* Per cent	*D* No.	*D* Per cent
1	2	5.6	7	19.4	15	41.7	12	33.3
2	6	46	2	15.4	3	23	2	15.4
3–4	3	21.5	5	35.7	5	35.7	1	7.1
over 4	10	66.7	2	13.3	2	13.3	1	6.7

TABLE XIV

Years at Polytechnic

Salary	1 No.	1 Per cent	2 No.	2 Per cent	3–4 No.	3–4 Per cent	Over 4 No.	Over 4 Per cent
A	2	9.5	6	28.6	3	14.3	10	47.6
B	7	43.7	2	12.5	5	31.3	2	12.5
C	15	60	3	12	5	20	2	8
D	12	75	2	12.5	1	6.2	1	6.3

Table XII shows that a small proportion of the men began their evening work at Polytechnic before they secured employment.

Table XIII shows a very decided trend toward increase in salary with increase in time spent at Polytechnic. Only 25% of the men having one year at Polytechnic receive *A* and *B* salaries, while 80% of the men who have spent over four years at Polytechnic receive *A* and *B* salaries. This is also shown by Table XIV.

YEARS AT POLYTECHNIC VS. AGE

TABLE XV

Age

Years at Poly.	+30 No.	+30 Per cent	25–30 No.	25–30 Per cent	22–24 No.	22–24 Per cent	20–21 No.	20–21 Per cent	−20 No.	−20 Per cent
1	7	9.6	23	31.5	16	21.9	9	12.3	18	24.6
2	1	3.8	6	23	10	38.5	5	19	4	15.4
3–4	1	4.5	6	27	7	32	7	32	1	4.5
over 4	9	23	19	48.7	10	25.6	1	2.6		

TABLE XVI

Years at Polytechnic

Age	1 No.	1 Per cent	2 No.	2 Per cent	3–4 No.	3–4 Per cent	Over 4 No.	Over 4 Per cent
−20	18	78.3	4	17.4	1	4.3		
20–21	9	40.9	5	22.7	7	31.8	1	4.5
22–24	16	37.2	10	23.3	7	16.3	10	23.3
25–30	23	42.6	6	11.1	6	11.1	19	35.2
+30	7	38.9	1	5.5	1	5.5	9	50

Undoubtedly salary increases in general with age so that the increase in salary noted in the preceding paragraph may be due to increase in age

SALARY VS. YEARS EMPLOYED

TABLE XVII

Salary

Years employed	*A* No.	*A* Per cent	*B* No.	*B* Per cent	*C* No.	*C* Per cent	*D* No.	*D* Per cent
1					4	57	3	43
2–3	1	7.7	2	15.3	5	38.5	5	38.5
3–5	4	17.4	6	26	7	30.6	6	26
6–7	4	33.3	3	25	3	25	2	16.7
over 7	12	54.5	5	22.7	5	22.7	0	

TABLE XVIII

Years Employed

Salary	1 No.	1 Per cent	2–3 No.	2–3 Per cent	3–5 No.	3–5 Per cent	6–7 No.	6–7 Per cent	over 7 No.	over 7 Per cent
A			1	4.8	4	19	4	19	12	57.1
B			2	12.5	6	37.5	3	18.7	5	31.2
C	4	16.7	5	20.8	7	29.2	3	12.5	5	20.8
D	3	18.8	5	31.2	6	37.5	2	12.5	0	

with years at Polytechnic. Table XV gives this comparison. Comparing Table XV with Table XIII it will be noted that there is no such decided increase in age as there is in salary. For instance, the percentage of each group over 25 years old from one year at Polytechnic to over four years

YEARS AT POLYTECHNIC VS. CHARACTER OF EMPLOYMENT

TABLE XIX

Character of Employment

Years at Poly.	Technical No.	Technical Per cent	Non-technical No.	Non-technical Per cent
1	20	50	20	50
2	11	73.3	4	26.7
3–4	17	89.5	2	10.5
over 4	19	79	5	21

TABLE XX

Years at Polytechnic

Char. of em.	1 No.	1 Per cent	2 No.	2 Per cent	3–4 No.	3–4 Per cent	over 4 No.	over 4 Per cent
Tech.	20	30	11	16.4	17	25.4	19	28.3
Non-tech.	20	64.5	4	12.9	2	6.4	5	16.1

are, respectively, 41.1%, 26.8%, 31.5%, and 71.7%, while the corresponding figures showing the percentage receiving *A* or *B* salaries are 25%, 61.4%,

57.2%, and 70%. This would seem to indicate a decided influence of education as well as age upon earning capacity.

Table XVII and XVIII show a rather uniform increase in salary with

YEARS EMPLOYED VS. AGE

TABLE XXI

Age

Years employed	+30 No.	+30 Per cent	25–30 No.	25–30 Per cent	22–24 No.	22–24 Per cent	20–21 No.	20–21 Per cent	−20 No.	−20 Per cent
1									6	100
2–3					6	50	3	25	3	25
3–5	0		8	33.3	8	33.3	7	29.2	1	4.2
6–7			6	33.3	6	33.3	3	16.6	3	16.6
over 7	4	15.4	17	65.4	2	7.7	3	11.5		

TABLE XXII

Years Employed

Age	1 No.	1 Per cent	2–3 No.	2–3 Per cent	3–5 No.	3–5 Per cent	5–7 No.	5–7 Per cent	over 7 No.	over 7 Per cent
−20	6	46.1	3	23.1	1	7.7	3	23.1		
20–21			3	18.8	7	43.7	3	18.8	3	18.8
22–24			6	27.3	8	36.4	6	27.3	2	9.1
25–30					8	25.8	6	19.4	17	54.8
+30									4	100

the number of years employed, although there are quite a few exceptions where high salaries are obtained after only a few years' employment and, on the other hand, low salaries are earned by many young men who have had long experience. For instance, in Table XVIII 4.8% of the group

CHARACTER OF EMPLOYMENT VS. YEARS EMPLOYED

TABLE XXIII

Character of Employment

Years employed	Technical No.	Technical Per cent	Non-technical No.	Non-technical Per cent
1	5	71.4	2	28.6
2–3	10	76.9	3	23.1
3–5	16	55.2	13	44.8
6–7	13	81	3	19
over 7	21	77.7	6	22.3

TABLE XXIV

Years Employed

Char. of em.	1 No.	1 Per cent	2–3 No.	2–3 Per cent	3–5 No.	3–5 Per cent	6–7 No.	6–7 Per cent	over 7 No.	over 7 Per cent
Tech.	5	7.7	10	15.4	16	24.6	13	20	21	32.3
Non-tech.	2	7.4	3	11.1	13	48.1	3	11.1	6	22.2

earning *A* salaries have worked only three years, while 20.8% of the group which is earning *C* salaries have worked more than seven years.

Table XIX as well as Table XX show a decided tendency toward entering technical employment in connection with education at the Polytechnic. These tables also indicate that by no means all students leave non-technical employment. Undoubtedly, chemistry is often studied for its cultural value and interest in the subject.

Tables XXI and XXII give the relation between age and years employed. These tables show great variation between the age at which this group of young men started working. Many of them evidently started working

SALARY VS. AGE

TABLE XXV

Salary

	A		*B*		*C*		*D*	
Age	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
−20					6	46.1	7	53.9
20–21			3	21.4	11	78.6	0	
22–24	5	27.7	5	27.7	6	33.3	2	11.1
25–30	13	56.5	5	21.7	2	8.7	3	13
+30	3	100						

TABLE XXVI

Age

	+30		25–30		22–24		20–21		−20	
Salary	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
A	3	14.3	13	61.9	5	23.8				
B			5	38.5	5	38.5	3	23		
C			2	8	6	24	11	44	6	24
D			3	25	2	17.7			7	58.3

when quite young and later found the means and opportunity offered by the Polytechnic to continue their education.

Tables XXIII and XXIV would seem to indicate a strong tendency for young men to remain in the kind of employment in which they started as there seems to be very little change in the percentage of those in technical employment with the number of years employed.

Tables XXV and XXVI show a fairly close correlation between salary and age. The relation is very much closer than between salary and years of employment. Apparently age is a much more important factor than experience with this group of young men.

Tables XXVII and XXVIII would indicate that age has no influence on the character of the employment as between technical and non-technical work.

Tables XXIX and XXX indicate that the young men in technical employment are receiving somewhat higher salaries than those in non-technical employment. For instance, in Table XXX, 30.9% of those in technical employment receive *A* salaries, while only 17.3% of those in non-technical employment receive *A* salaries, and a much larger per-

AGE VS. CHARACTER OF EMPLOYMENT

TABLE XXVII

Character of Employment

Age	Technical		Non-technical	
	No.	Per cent	No.	Per cent
−20	10	76.9	3	23.1
20–21	12	66.7	6	33.3
22–24	16	72.7	6	27.3
25–30	25	75.7	8	24.3
+30	2	50	2	50

TABLE XXVIII

Age

Char. of em.	−20		20–21		22–24		25–30		+30	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Tech.	10	15.4	12	18.5	16	24.6	25	38.4	2	3.1
Non-tech.	3	12	6	24	6	24	8	32	2	8

centage of the non-technical young men receive *D* salaries than those in technical employment.

This is very interesting in view of the rather widespread impression that technical men are poorly paid as compared with those in other employment. This is certainly not true of the young men attending the Polytechnic Institute.

SALARY VS. CHARACTER OF EMPLOYMENT

TABLE XXIX

Character of Employment

Salary	Technical		Non-technical	
	No.	Per cent	No.	Per cent
A	17	81	4	19
B	10	62.5	6	37.5
C	18	72	7	28
D	10	62.5	6	37.5

TABLE XXX

Salary

Char. of em.	*A*		*B*		*C*		*D*	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Tech.	17	30.9	10	18.2	18	32.7	10	18.2
Non-tech.	4	17.3	6	26.1	7	30.4	6	26.1

Conclusions

It is realized that these data are not extensive enough to enable one to draw broad conclusions. They do, however, show interesting tendencies and are therefore considered worthy of recording. The more important tendencies shown by this study are as follows:

(1) Technically employed students do better scholastic work as evidenced by their grades than do non-technically employed students.

(2) Technically employed students receive better salaries than the non-technically employed students.

(3) Age is the most important factor in determining a student's earning capacity.

(4) Students with good scholastic grades receive higher salaries than students with fair or poor scholastic grades.

New Light Cell May Aid Accurate Television. A new form of photoelectric cell for converting light waves to electric impulses, using the metal cesium instead of potassium, may prove of value in television because its response is more similar to that of the human eye. The new cell was described by V. Zworykin and E. D. Wilson, of the Westinghouse Electric and Manufacturing Co., at the joint meeting of the American Physical Society and Optical Society of America, held recently at Columbia University.

It has been known for some time that cesium offers a number of advantages for use in photoelectric cells, said Mr. Zworykin. The difficulties of handling prevented its use. With the aid of his colleague, he has overcome these difficulties by combining the cesium with magnesium. The magnesium binds the invisible cesium layer to the wall of the glass bulb, and also an electrical connection with it.

Its sensitivity is higher than that of other cells. Also, the color to which it is most sensitive comes very close to that to which the eye best responds. The eye is most sensitive to yellow light. So is pure cesium. The cesium-magnesium, as used in the new cell, responds best to bluish green light, while the ordinary potassium cell responds best to deep blue. The use of such a cell as the new one in television would give an image with color values closely approaching those of the eye.—*Science Service*

Life Is Electrical, Scientist Claims. The spark of life is probably a spark of electricity in the opinion of Dr. G. W. Crile of Cleveland, who addressed the American Philosophical Society at its recent meeting in Philadelphia. The driving energy or vital force, call it what you will, the thing that makes our works go, is essentially electric in nature, Dr. Crile declared.

All living things have an electric potential. At death this falls to zero and remains there. Oxidation is necessary to maintain this potential in the cells. It is an electric force that builds up and maintains the form and structure of all living cells.

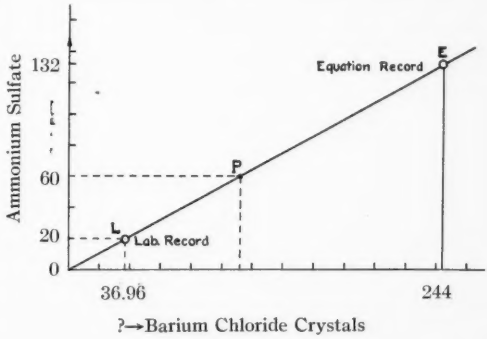
The principal difference between that electric potential which is life and that electric potential present in non-living things like a storage battery is that the living potential is changed spontaneously and according to environment, Dr. Crile said.—*Science Service*

MORE ABOUT PROBLEMS AND GRAPHS

EUGENE R. DAVIS, WILLIAM I. DICKINSON HIGH SCHOOL, JERSEY CITY, NEW JERSEY

Mr. Stone, in a recent issue of the JOURNAL OF CHEMICAL EDUCATION, described an interesting method of teaching the solution of problems by the use of graphs. The graph is helpful in reviewing problems of this type—How many grams of barium chloride, crystallized, will exactly precipitate 20 grams of ammonium sulfate?

Say to the class: "A chemist dissolves exactly 20 grams of ammonium sulfate in water and adds a solution of barium chloride crystals, a little at a time, waiting each time for the precipitate to settle, until a drop of the barium chloride makes no more precipitate. He had 40 grams of the barium chloride crystals dissolved in 250 cc. of water. By measuring the volume left, he calculates that he used 36.96 grams. His record reads: 20 grams of ammonium sulfate required 36.96 grams of barium chloride crystals."



After the class has the picture of this laboratory work sharply defined, have these weights plotted on cross-section paper and on the blackboard as shown in the figure, and mark point L, the point of Laboratory Record, because, knowing that point L means 20 grams of ammonium sulfate were matched chemically by 36.96 grams of barium chloride crystals, we can solve problems of the following type: How many grams of barium chloride crystals would exactly use up 60 grams of ammonium sulfate. Ans.: 36.96×3, or 110.88 grams.

Draw the line OL, extend it, and mark point P, representing 60 grams of ammonium sulfate and 110.88 grams of barium chloride crystals. Erase point L and the figures 20 and 36.96 from the graph on the blackboard, and propose this problem: If 110.88 grams of barium chloride crystals precipitate 60 grams of ammonium sulfate, how many grams of the barium chloride would be needed for 70 grams of ammonium sulfate? Let the class locate the point for 70 on line OLP and then trace down for the corresponding value. The classes can now see that the point L, that of the original laboratory record, can be dropped, but that problems can still be solved if we have some one point on the line OLP.

Explain, then, that if crystals of barium chloride are made up using atoms or "standard packages," a weight of 244 must be taken, and that this weight is represented by $BaCl_2 \cdot 2H_2O$. How many grams of ammonium sulfate will match 244 grams of the barium chloride crystals? Ans. 132 grams. This corresponds to the formula $(NH_4)_2SO_4$.

These figures (244 and 132) give us point *E* on the graph. Call this the point of Equation Record. Make certain that every one understands that this point is the only record pupils can find to use in solving these problems. Write:

$$\underset{132}{(NH_4)_2\,SO_4} + \underset{244}{BaCl_2 \cdot 2H_2O} \longrightarrow BaSO_4 + ?$$

and have the class practice problems such as: If 244 grams of barium choride crystals are equivalent to 132 grams of ammonium sulfate, how many grams of ammonium sulfate are equivalent to 110.88 grams of barium chloride crystals? Again, 300 grams of barium chloride crystals are equivalent to what weight of ammonium sulfate?

The emphasis of this suggested drill is on the necessity for learning how to write equations if problems of the types given are to be solved.

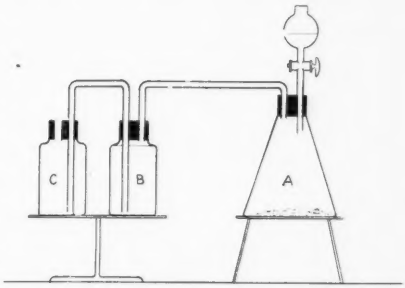
The Institute of Metals. The Institute of Metals, founded for the study of Non-Ferrous Metallurgy in 1908, which recently held its twenty-first annual meeting, had an initial membership of about 250. Today the roll of its members exceeds 2000, of whom about two-thirds are British and Empire members, while the remaining one-third consists of foreign members. At the time of its formation many doubts were expressed whether such an institute could be formed and maintained, and whether it would fulfil any really useful function. When the successful career of the Iron and Steel Institute was cited as an encouraging example, the doubters pointed out that the non-ferrous industries were much smaller, less wealthy, and less advanced from a technical and scientific point of view. It was even feared that manufacturers might not wish to support such an institute and that they would decline to allow the members of their staffs to take part in its meetings for fear of divulging confidential information. Fortunately, the small band of enthusiastic founders of the Institute did not permit themselves to be deterred by such misgivings, and as soon as a start had been made it became abundantly clear that a real need existed for an institute dealing with the non-ferrous metals. From the very beginning the Institute prospered. Its membership began to grow steadily and still continues to increase today, while the value of its work and influence stands fully recognized both in Great Britain and abroad. Its first three presidents were the late Sir William White, the late Sir Gerrard Muntz, and the late Prof. W. Gowland, representing respectively the user, the manufacturer, and the scientific student of metals. This order of rotation in filling the presidential chair has been followed, with a few exceptions in special circumstances, throughout the past history of the Institute. It is intended to emphasize the fact that the Institute seeks to serve the interests of all those directly concerned with the non-ferrous metals, whether as users, manufacturers, or scientific investigators and teachers of metallurgy.—*Nature* (London), **123,** 422–3 (Mch. 16, 1929).

A DEMONSTRATION EXPERIMENT WITH HYDROGEN CHLORIDE

CHARLES H. STONE, ENGLISH HIGH SCHOOL, BOSTON, MASSACHUSETTS

Although the effect of hydrogen chloride upon the throat and nasal passages is much less irritating and disagreeable than that produced by chlorine, it is nevertheless unpleasant and should be avoided when possible. The apparatus shown below has been used on the demonstration desk in the writer's classes for a number of years with complete satisfaction. This apparatus entirely prevents the escape of hydrogen chloride into the air of the room and at the same time illustrates several interesting phenomena.

In the generator flask are placed about twenty-five grams of common salt, which is moistened with about five cubic centimeters of water. In the dropping funnel are placed about ten cubic centimeters of concentrated sulfuric acid. Bottle *B* is filled nearly full of water but bottle *C* is empty. The tube leading from the generator to bottle *B* should extend barely through the stoppers but the tube leading from bottle *B* to bottle *C* should extend nearly to the bottom of both bottles. There need be no stopper in bottle *C*. The attention of the class should be directed to these points and to the fact that the generator at the beginning of the experiment contains air in addition to the salt and water.



The stopcock is now opened and some sulfuric acid allowed to fall on the moistened salt. Action will be seen to take place. Presently the water in *B* will go over into *C*. When all the acid has been added and the stopcock is closed it will be seen, after the action in *A* has continued for some time, that the water in *C* flows back again into *B*. The attention of the class should be directed to these changes and the explanation sought.

When the action in *A* slackens, heat may be applied. The liquid in *B* may pass over again into *C* but will presently return to *B*. Careful examination of the liquid in the bottle will reveal the downward flow of the acid through the water. When no further action is evident in *A* after continued heating, the heat may be removed. The liquid in the bottles will finally remain in *B*.

The liquid finally remaining in *B* may now be examined and tested for its action on indicators, on zinc, and on solutions of silver, lead, and

mercurous nitrates. It should react vigorously with zinc but may not be sufficiently concentrated to react with oxidizing agents to form chlorine.

If desired, the generator may be filled with water through the dropping funnel to absorb any gas remaining in the generator before emptying out the contents. The solution thus formed in *A* may be crystallized to obtain the sodium sulfate.

Airplanes Pursue Dangerous Insects. Airplane pursuit tactics are being used by the U. S. Department of Agriculture to discover the flight habits of destructive insects. The airplanes equipped with insect traps were recently placed in service in Mexico to study the movements of the pink boll worm moths which are suspected of unlawfully emigrating to this country.

The pink boll worm is one of the most destructive pests of cotton, and has long been combated on the border between Texas and Mexico by the quarantine service of the Federal Horticultural Board. It was felt that the cotton-growing regions of the southwest could be made more secure against the invasion of this and other bugs if more were known about the flight of the moths from the heavily infested regions.

The traps consist of a sticky fly paper preparation which holds the moth when it flies against it. The airplanes are sent over territory above which the moths are believed to be flying and, by opening the trap, specimens are obtained. Age, sex, and direction of flight of the insects from infested cotton fields are noted and the scientists believe these data will enable them to determine the season and direction in which the moths travel. The abundance of the moths in the upper air and the altitude which they attain will also indicate the distance they may travel.

Arrangements were made with the Mexican government which allowed the airplanes to fly across the border and conduct the investigations in Mexico without interference. In fact, the Mexican Department of Agriculture is giving hearty coöperation in all the investigations.—*Science Service*

Refrigeration to Cool Mines Over Mile Deep. Refrigeration, which has entered the kitchens of thousands of homes in the past few years, is now about to penetrate the depths of metal mines to make working conditions a mile or more below the earth's surface more bearable for those who extract valuable ore from the rocks.

At present mines cannot be successfully worked deeper than 7000 to 8000 feet because at those elevations workable atmospheric conditions cannot be maintained by circulation of the air alone, R. W. Waterfill, ventilating engineer of Newark, N. J., recently told the American Institute of Mining and Metallurgical Engineers. Air circulated from the surface to the deep workings is heated by compression and by the heat of the rocks which is given off in increasing quantity as the depth increases.

By placing a specially designed refrigerating and air-treating unit underground near the workings to cool the air and rob it of its humidity, mining can be carried on at greater depths, Mr. Waterfill predicted.

Tests have shown that when the temperature is over 94°F. the wearing of clothing is beneficial as it promotes cooling through greater evaporation. Moreover, when the temperature is 100 degrees and the air is saturated with moisture, moving the air with a fan gives no relief. Under conditions of 100 degrees temperature and 100% humidity, the work that can be accomplished is only 40% that when the air is 90 degrees and completely saturated and only 30% that when the air is 100 degrees and only 60% saturated with moisture.—*Science Service*

A DEVICE FOR STIRRING WITHIN A SEALED CONTAINER

LEOPOLD SCHEFLAN, LONG ISLAND UNIVERSITY, BROOKLYN, N. Y.

A simple and efficient method of stirring within a sealed container is to use a pulsating current which passes through a solenoid and alternately raises and drops the stirring mechanism.

It has been found that a "flasher button" with a capacity of 60 watts and 110 volts may be used to produce such a current.* The button works on the following principle: the current comes in at *A* (Figure 1), flows through the coil which makes contact at *B*, and then leaves at *E* on the other side of the button. The strip *C-D* consists of two pieces of different metals firmly attached to each other. At the start a small fraction of the current passes through the coil, heating *C-D* which then bends over until it makes contact at *B*. As soon as this happens, nearly all the current passes through *C-D* and practically none flows through the coil. Now the

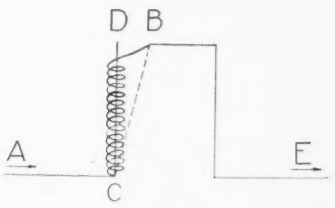


FIGURE 1

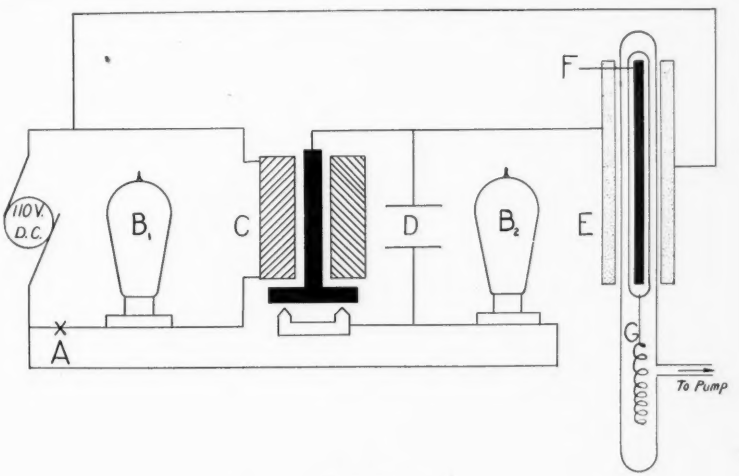


FIGURE 2

coil cools down. This cools *C-D*, which straightens so that the contact between *B* and *D* is broken again, etc.

* The appliance actually used in the set-up was a "Diamond Flasher Button," manufactured by the General Appliance Corporation, San Francisco, California.

The set-up which was used to raise and drop the stirrer by means of this flasher button is indicated in Figure 2. In this figure, A is a socket containing the flasher button; B_1 and B_2 are light bulbs which reduce the current to the proper value. C is a relay which makes and breaks the current through the solenoid. D is a condenser which prevents sparking across the relay. E is a solenoid. F is a rod of iron sealed inside of a glass tube to protect it from the reaction mixture. G is a platinum stirrer sealed to the piece of tubing which contains F.

The degree of stirring may be regulated by varying the current through the solenoid.

Artificial Analog of Rubber. The investigation of the problem of the chemistry of rubber by Staudinger and his school has been complicated in the past, on the natural side by the very great susceptibility of caoutchouc to oxidation, and on the synthetic side by the fact that the synthetic caoutchouc produced by condensation of the hydrocarbon isoprene may have a very different structure from the natural material, owing to the possibility of molecules uniting together into complex three-dimensional systems. A new approach to the subject is described by Prof. Staudinger in the January *Berichte* (vol. **62,** pp. 241–263). Instead of isoprene, the aromatic compound styrene is condensed. This, being a benzene derivative, cannot furnish a true caoutchouc, but the condensed product which it gives, *polystyrene*, may be regarded as a "model" of the natural substance, and can be accurately investigated since its constituent groups can link together only in one single chain. An interesting discovery is that if the condensation is carried out at high temperatures, for example, 240°C., the product is relatively simple, being composed of some thirty units, whereas if the styrene is condensed slowly at ordinary temperatures it yields a very complex, colloidal substance, composed of some hundred thousand units, and resembling natural caoutchouc. All intermediate degrees of complexity are obtainable by varying the temperature and the time of condensation, and at any temperature the product obtained is a complex mixture of numerous members of a series, comparable with the series of natural paraffins; the most highly condensed products, and these only, resemble caoutchouc in viscosity, and in elastic swelling properties. Professor Staudinger concludes that natural caoutchouc is built up on a similar plan of polystrene, and that it contains long chains of some thousand molecules of the unit "polyprene" (C_5H_8).— *Nature* (London), **123,** 472 (Mch. 23, 1929).

Einstein's Fiftieth Birthday. The fiftieth birthday of Prof. A. Einstein occurred on March 14th, and brought congratulations from all parts of the world. The German Chancellor hailed him as "Germany's great savant," and the Berlin municipality gave him the life tenancy of a pleasantly situated mansion. The University of Paris conferred an honorary degree. The Zionists are to plant an "Einstein Wood" near Jerusalem. Never before has the name of a scientific worker meant so much to the average man. Yet the creator of relativity and of the unitary field theory remains a quiet and retiring personality who dislikes publicity and society. His appearance suggests a musician, and indeed his love of music is one of his leading characteristics. Last year he gave a violin recital for a charity. He finds much pleasure in Russian literature, and appreciates modern ideas in architecture. He is an ardent sympathizer with efforts for world peace. Recently his health has not been good, but he says, "Illness has its advantage: one learns to think. I have only just begun to think."— *Nature* (London), **123,** 464 (Mch. 23, 1929).

WINNERS OF PRIZE ESSAY CONTEST, 1928-29*

COLLEGE CONTEST

The Relation of Chemistry to Health and Disease

Name	College	Subject	Place
MARION P. ADAMS	Antioch College, Yellow Springs, Ohio	The Relation of Chemistry to Health and Disease	(1)
LILLIAN CRAVENS	University of Arkansas, Fayetteville, Ark.	The Relation of Chemistry to Health and Disease	(2)
DANIEL G. HOWELL	North Dakota State College, Fargo, N. D.	The Relation of Chemistry to Health and Disease	(3)

The Relation of Chemistry to the Enrichment of Life

ROSSER REEVES	University of Virginia, Charlottesville, Va.	Chemistry and Its Relation to the Enrichment of Life	(1)
WILLIAM W. KNOX	University of Michigan, Ann Arbor, Mich.	What a High-School Class Learned about Chemistry	(2)
SALLY HARRIS	College of the City of New York, N. Y.	Chemistry and the Younger Generation	(3)

The Relation of Chemistry to Agriculture

CHARLOTTE NISSLEY	Goucher College, Baltimore, Md.	The Relation of Chemistry to Agriculture–Insecticides	(1)
MARY LOUISE CARLL	Goucher College, Baltimore, Md.	The Relation of Chemistry to Agriculture	(2)
LAWRENCE SIMERL	University of Illinois, Urbana, Ill.	The Relation of Chemistry to Agriculture	(3)

The Relation of Chemistry to National Defense

MARY P. WOOLVERTON	Goucher College, Baltimore, Md.	The Relation of Chemistry to National Defense	(1)
SISTER M. ETHELBURG LEUSCHEN, O.S.B.	Mt. St. Scholastica College, Atchison, Kansas	The Relation of Chemistry to National Defense	(2)
DOMINADOR JUSTINIANI	Silliman Institute, Dumaguette, Philippine Islands	The Relation of Chemistry to National Defense	(3)

* It was necessary to eliminate, because of excessive length, several excellent essays submitted.—*Committee on Awards*

The Relation of Chemistry to the Home

Name	College	Subject	Place
ROSALIE E. O'HERRON	University of Illinois, Urbana, Ill.	Disinfection and the Preservation of Food in the Farm Home	(1)
ROSALIA L. CONLEE	Illinois Woman's Coll., Jacksonville, Ill.	The Kitchen 1828 vs. the Kitchen 1928	(2)
ELSA SEIBERT	Thiel College, Greenville, Penna.	The Relation of Chemistry to the Home	(3)

The Relation of Chemistry to Industry

H. DONALD BERGENER	Yale University, New Haven, Conn.	The Relation of Chemistry to the Rubber Industry	(1)
KATHERINE GRAY BRUGH	University of Richmond, Richmond, Va.	The Relation of Chemistry to the Tobacco Industry in the United States	(2)
MARY DORCAS WHEELER	Greenville College, Greenville, Ill.	Chemistry as Related to the Artificial Silk Industry	(3)

NORMAL SCHOOL AND TEACHERS' COLLEGE STUDENTS

The Relation of Chemistry to Health and Disease

JOHN R. HASLAM	Indiana State Normal School, Terre Haute, Indiana	The Relation of Chemistry to Health and Disease	(1)
RUSSELL E. JONAS	Northern State Teachers' College, Aberdeen, S. D.	Chemistry in Relation to Health and Disease	(2)
MARIE WALDRAM	Ricks College, Rexburg, Idaho	The Relation of Chemistry to Health and Disease	(3)

The Relation of Chemistry to the Enrichment of Life

JOE JONES	Peru State Teachers' College, Peru, Nebraska	The Relation of Chemistry to the Enrichment of Life	(1)
LOIS VERA GENTRY	Asheville Normal, Asheville, North Carolina	Chemistry in Relation to the Enrichment of Life	(2)
ESTELLA F. KELLEY	Western State College, Gunnison, Colorado	The Relation of the Chemistry of Glass to the Enrichment of Life	(3)

The Relation of Chemistry to Agriculture

Name	College	Subject	Place
RALPH D. SPEARS	Slippery Rock State Teachers' College, Slippery Rock, Penna.	Fixation of Nitrogen	(1)
DOROTHY G. GREENBANK	Western State College, Gunnison, Colo.	The Relation of Chemistry to Agriculture	(2)
MAX E. THOMPSON	Western Illinois State Teachers' College, Macomb, Ill.	The Relation of Chemistry to Farm Relief	(3)

The Relation of Chemistry to National Defense

ELVERE CONNER	State Teachers' College, Fredericksburg, Va.	Chemistry in Relation to National Defense	(1)
JOHN URBAN	Kent State Normal School, Kent, Ohio	The Relation of Chemistry to National Defense	(2)
HORACE DUDLEY, JR.	State Teachers' College, Springfield, Mo.	The Relation of Chemistry to National Defense	(3)

The Relation of Chemistry to the Home

HENRY L. PRICHARD	The Morehead State Normal School and Teachers' Coll., Morehead, Kentucky	The Relation of Chemistry to the Home	(1)
DEAN FITZGERALD	Southwest Missouri State Teachers' Coll., Springfield, Mo.	The Relation of Chemistry to the Home	(2)
OLIVER G. EDWARDS	Louisiana State Normal Coll., Natchitoches, Louisiana	The Relation of Chemistry to the Home	(3)

The Relation of Chemistry to Industry

HERMAN STEFFAN	Western State College, Gunnison, Colo.	The Relation of Chemistry to the Development of Natural Resource	(1)
WILLIAM HAMM	Maryhurst Normal School, Kirkwood, Mo.	The Inter-Relation of Chemistry and Applied Electricity	(2)
MARION E. WARNER	Peru State Teachers' Coll., Peru, Nebraska	Chemistry in Connection with the Automobile Industry	(3)

The Chemistry Student

AN EXPERIMENT ILLUSTRATING VOLTAIC POLARIZATION*

H. P. Cady and Robert Taft, University of Kansas, Lawrence, Kansas

One of the most difficult ideas to convey to the student of electrochemistry is that polarization occurring in voltaic cells is not due primarily to the increased resistance caused by the formation of gas at the electrodes. The reason for the difficulty is no doubt of historical origin. The early investigators on Volta's cells recognized that the drop in voltage, which occurred when a cell was used, was accompanied by the formation of gas at the electrode (or electrodes) and stated that the polarization, *i. e.*, the drop in potential across the cell with use, was due to the high resistance built up by the insulating layer of gas bubbles. This explanation has been continued, until it is found at the present day in the majority of textbooks on general physics and even in chemical texts treating this topic.

If polarization be defined as a decrease in the potential of a voltaic cell due to changes produced during the passage of the current, we can, for purposes of arriving at a satisfactory explanation of polarization, consider that the phenomenon is due to at least three effects: (1) concentration changes around the electrodes, *i. e.*, concentration polarization; (2) a change in the nature of the electrode (or electrodes), *i. e.*, chemical polarization; (3) an increase in the internal resistance of the cell due to a film of gas, other non-conducting material, etc., *i. e.*, mechanical polarization. In addition to these three, another effect which opposes the passage of the current is recognized and is classed by most students of electrochemistry under the heading overvoltage.[1]

The polarization effects, particularly the first and second, may be clearly shown by a simple study of one of Volta's original cells. In Volta's cell, copper serves as the positive electrode, zinc as the negative, and the electrolyte consists of dilute sulfuric acid. If a small current be taken from these cells and voltage-time readings be made and plotted, results such as those shown in Figure I will be obtained.

If the copper electrode is cleaned before use, *i. e.*, freed from copper

* Presented before the Division of Chemical Education at the St. Louis Meeting of the American Chemical Society, April 18, 1928.

[1] Overvoltage may be defined as a deviation from the equilibrium electrode potential due to incomplete reversibility of the electrode reaction. Cf. Creighton, "Electrochemistry," John Wiley & Sons, Inc., New York City, **1928,** 2nd ed., p. 247.

compounds at its surface, data as shown in Figure I-4 will be obtained. If the electrode contains some copper compounds initially and these are not removed, results as shown in Figure I-1 may be obtained. If the compounds (oxidized copper) are present in still greater quantity, then data as represented by the curve in Figure I-3 may be obtained. Finally, if copper sulfate (*i. e.*, a large supply of Cu^{++}) is actually added to the electrolyte, the voltage of the cell remains at its high initial value for long periods of time. (See Figure I-2.) On the basis of the definition of polarization given these could be explained as follows:

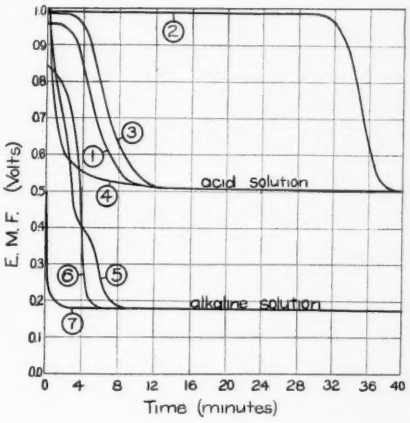


FIGURE I

The cell $Cu|H_2SO_4|Zn$ has its initial value (about 1 volt) due to the fact that the positive electrode is actually

$$Cu|Cu^{++}$$

and the negative

$$Zn|Zn^{++}$$

The initial copper-ion concentration in those cases where it is not actually added, is produced as a result of the solution of the copper compounds on the surface of the electrode. When the cell is used then the reaction at the positive electrode

$$Cu^{++} + 2\epsilon = Cu^{\circ}$$

takes place, tending to remove Cu^{++}. When these are used up the next available ion discharges, which is in this case H^+, but the potential

$$H_2|H^+$$

is much lower than $Cu|Cu^{++}$ and consequently the cell will have a smaller potential due to a change in the nature of the electrode. The original slow slope is due therefore to a change in the concentration of the ions around the electrodes, the copper-ion concentration diminishing, the zinc-ion concentration increasing; that is, to concentration polarization. The sudden break, however, is due to chemical polarization for the cell becomes then not

$$Cu|Cu^{++}|H_2SO_4|Zn^{++}|Zn$$

but

$$H_2|H^+|H_2SO_4|Zn^{++}|Zn$$

Of course, at this lower potential hydrogen is liberated but it is not the increased electrical resistance of the hydrogen bubbles that produces the drop in potential across the cell. Actual measurements of the cell to be described have shown that within the range of experimental error the resistance of the cell remained the same, *i. e.*, 0.5 of an ohm. To produce a difference of 0.5 of a volt (the measured value in the case mentioned) the internal resistance should have increased by 50 or more ohms if the polarization were due solely to this cause.

The variation in the time necessary to reduce the cell potential to its final value in the cases 4, 1, 3, and 2 (Figure I) are, of course, due to the increasing amounts of copper ion present in each case. When copper compounds are actually added to the cell (2, Figure I) the voltage maintains a high value for a considerable period of time (depending, of course, on the amount of copper compound originally added). It has been the custom to speak of those substances which tend to maintain the cell at values close to their original values as depolarizers. Copper ion is therefore a depolarizer for this simple voltaic cell as it prevents chemical polarization, that is, a change in the nature of the positive electrode. On the older view, depolarizers were substances which removed the gas from the electrodes as fast as it was formed. From the modern view, depolarizers are substances which produce higher electrode potentials at the positive electrode than hydrogen; at the negative electrode a depolarizer would be any substance producing a lower electrode potential than oxygen. Or, to put it another way, a depolarizer is a more powerful oxidizing agent than hydrogen ion, or a more powerful reducing agent than hydroxyl ion.

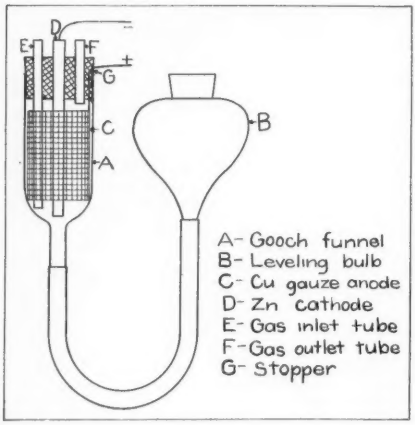


FIGURE II

To show these results as a laboratory experiment, a cell may be made from ordinary laboratory apparatus as shown in Figure II.

In this figure (II), *A* is a Gooch filter funnel connected by rubber tubing to the leveling bulb *B*. The copper electrode *C* is a piece of copper gauze bent to fit the inside of the funnel, one strand of the gauze being carried through the stopper *G* to make electrical contact. The copper gauze should not be cleaned, *i. e.*, there should be a good oxide coating on its

surface to insure the presence of copper ions when brought in contact with the electrolyte. *D* is the zinc electrode which is amalgamated before use. *E* and *F* are glass tubes for introducing and removing natural gas. The voltmeters we have used for the voltage measurements are Model 280 Weston instruments. These are particularly satisfactory for this purpose as they draw on closed circuit an amount of current sufficient to show the polarization effects in a reasonable length of time. Of course other types of voltmeters could be used but if they are of higher resistance than the Model 280 instruments[2] some means of drawing a small current (0.01 to 0.02 ampere) should be provided.

The electrolyte is placed in the leveling bulb closed by a screw clip, and upon closing the voltmeter circuit the solution is allowed to flow around the electrodes. We have used 6 *N* sulfuric acid as the electrolyte as this was the most convenient to use. Other concentrations of acid might of course be used. When the copper gauze is completely immersed (save for the single strand) voltage readings are taken at one- or two-minute intervals. After the voltage reaches a constant value for some minutes the readings are discontinued.

In order to vary the amount of copper compound present, the electrolyte is removed and the electrodes allowed to stand exposed to air for two or three minutes, the reaction

$$2Cu + 2H_2SO_4 + O_2 = 2CuSO_4 + 2H_2O$$

taking place upon the copper as it is still wet by the acid. The electrolyte may be returned and another set of time-voltage data obtained. To obtain the results with the "clean" electrode, the cell is discharged to its lowest voltage value and natural gas introduced as the electrolyte is slowly removed by lowering the leveling bulb. The function of the gas is to provide an oxygen-free atmosphere. The electrolyte is removed from the leveling bulb and gas bubbled through it in order to free it as much as possible from dissolved oxygen. This dissolved oxygen would oxidize some of the copper to copper compound. Upon returning the oxygen-free electrolyte and taking another set of time-voltage data results such as are shown diagrammatically in Figure I-4 are obtained. The initial reading of about 1 volt followed by the almost immediate drop indicates that, despite the precautions observed, a trace of copper had been oxidized.

In order to obtain data as shown in Figure I-2, enough copper sulfate should be added to color the solution distinctly blue.

It is also instructive to use the same pair of electrodes in alkaline solution (2*N* NaOH) thus forming a Lalande type cell. Results such as are shown in Figure I-5, -6, and -7 can be obtained.

[2] According to the manufacturer, the resistance of the Model 280 voltmeter is approximately 62 ohms per volt.

Figure I-5 shows the initial electrode with its copper oxide coating having the initial value of approximately 1.2 volts. This is rapidly used up but soon reaches a new level in the neighborhood of 0.3 volt and is due evidently to the electrode

$$O_2|OH^-$$

the oxygen being that present dissolved in the electrolyte; for if the electrolyte is removed and freed of oxygen, the copper electrode in the meanwhile being allowed to stand exposed to air, data such as are shown in Figure I-6 will be obtained. The "hump" at 0.3 volt is clearly missing. It will also be noticed that the initial value is not as high as the original value, the reason lying in the fact that, in the presence of alkali, copper is oxidized to cuprous oxide, so that the positive electrode is

$$Cu|Cu^+$$

rather than

$$Cu|Cu^{++}$$

The very rapid drop to the final value, Figure I-7, is obtained in the same way as described for Figure I-4. It should also be noted that the final value of the cell, which is of the same type as that finally obtained in the acid solution

$$H_2|H^+|NaOH|Zn^{++}|Zn$$

is much lower than that in the acid solution. This is due, of course, to the smaller hydrogen-ion concentration in the alkali cell, corresponding to a lower positive electrode potential. The two sets of final results, however, are not altogether comparable as the electrode potential of the negative electrode is certainly not the same in the two solutions, although they cannot be greatly different.

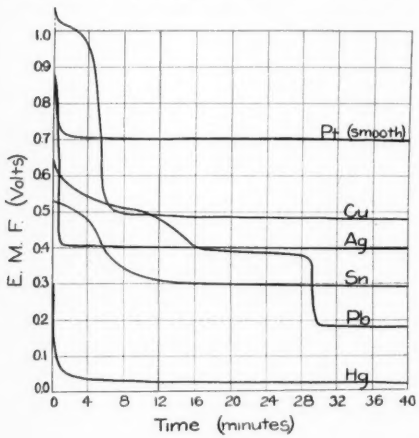


FIGURE III

The special polarization effect which is spoken of as overvoltage may also be illustrated by a modification of the same experiment. If other metals are substituted for copper in either cell, the final value, that is, the hydrogen value, will be found to be different from that obtained with copper. The results obtained by using six different metals as the positive electrode in dilute sulfuric acid are shown

in Figure III. Thin sheet metals were used, the area of each being approximately 36 square cm. A comparison of the final e. m. f. of the six different cells will show the order of overvoltage at approximately the same current density. As the current was less than 0.01 of an ampere in any case, the overvoltages should correspond to those values determined by static methods.[3] Using Caspari's value of 0.09 volt as the overvoltage of hydrogen against smooth platinum, the overvoltages of the other five metals by difference are as follows:

Positive electrode of cell	Final e. m. f.	Overvoltage of hydrogen
Pt	0.71	0.09 (assumed)
Cu	0.48	0.32
Ag	0.41	0.39
Zn	0.28	0.52
Pb	0.18	0.62
Hg	0.02	0.78

The overvoltages were calculated by subtracting the final e. m. f. of the cell from that of platinum and adding 0.09 to the difference. A comparison of these values with those of Caspari's are given below:

HYDROGEN OVERVOLTAGE

Metal	Caspari	C. and T.
Pt (smooth)	0.09	...
Cu	0.23	0.32
Ag	0.15	0.39
Sn	0.53	0.52
Pb	0.64	0.62
Hg	0.78	0.78

Fair agreement is shown except in the case of silver, which is not in the same order as in our list. A number of determinations have been made for this particular cell, giving results showing agreement within a few hundredths of a volt. The silver used is that furnished to the jewelry trade and marked 9995 fine. It should be borne in mind that the discrepancies such as are shown in the case of silver and copper could be attributed to either the purity of the metal or the condition of the surface, as it is well known that both of these factors, as well as the method used, determine the actual value of hydrogen overvoltages obtained by different investigators.

[3] Such as that used by Caspari, *Zeit. Phys. Chem.*, **30,** 89 (1899).

The chemist of the future is unlikely to be a solitary worker, and his investigations will be conducted with his colleagues: the physicist, the physiologist, and the engineer. —SIR JAMES C. IRVINE

A SUCCESSFUL CHEMISTRY CLUB INITIATION

ORVILLE WALTERS, ENID HIGH SCHOOL, ENID, OKLAHOMA

It may be commonly observed that an exclusive group is more sought after than one open to practically any one. This seems therefore defense enough for a few restrictions to membership in a high-school chemistry club. Some of the requirements which have been tried and found successful are: membership by election, a scholastic standing in the subject of over 80, a required attendance at six meetings and initiation before being allowed to wear the emblem of the club. Any member missing more than three weekly meetings each semester without good excuse is dropped.

The initiation may not only be a useful end in itself, but if rightly planned may give much impetus to the work of the club. An event of this sort may be worth describing in detail.

Initiates are notified of the time and place by notes written in dilute sulfuric acid, the borders being decorated with various symbols of alchemy drawn in cobalt chloride solution. Heating brings out the two-color effect.

The members are divided into two groups; attendants, who keep one position throughout the ceremony, and ushers, who conduct the candidates through. As they arrive, students to be initiated are directed to an out-of-the-way room until all are assembled. They are then led blindfolded, one at a time, to the Corridor of Superstition where their course begins. Only one initiate is allowed in any room at a time, but it is possible to have five or six undergoing the various ordeals simultaneously, each part of the ceremony being in a separate room. This requires the use of six rooms, one for the Corridor of Superstition, and one for each Ordeal of the Five Senses, though if only a few are to be initiated, a much smaller space may be used.

The Corridor of Superstition is lighted only by a new moon, a box hung high in the room with the crescent cut out and covered with amber glass or yellow paper. A small bulb is placed inside and a rheostat attached in the circuit. The attendant is behind a screen and speaks through a megaphone or bristol-board cornucopia. The corridor, which may be a narrow room or hallway, is hung with white sheets bearing varied emblems of superstition. There may be Hallowe'en decorations: witches, black cats, bats and owls, broken mirrors, "Friday," "Thirteen," skeletons, a ladder, an open umbrella, etc. One or two live black cats improve the atmosphere wonderfully, and one or more plaster busts shrouded in sheets except the face are decidedly effective.

The usher leads the initiate, rapping at each door for admittance.

There is no laughing or talking except the spoken ritual, which should be given impressively. A suggested ritual follows:

Attendant: Who comes?

Usher: A candidate for admission to fellowship with the Alchemists.

Attendant: Advance, Candidate, and hearken earnestly to the words which shall be spoken. You now stand at the threshold of the Chamber of Superstition. As you enter this chamber with its array of age-old and out-worn superstitions, and gaze for the last time upon these objects of delusion and dread, remember that they symbolize the mind of childhood—unthinking, unreasoning fear of things which are not understood. The positive knowledge of science has unshackled man's mind from these fetters of terror at the unknown. Awe and dismay have given way to the certainty of truth, and through science man may now deride the error which has mocked his age of ignorance. In entering this Chamber of Superstition, you typify a final farewell to superstitious beliefs. Is it your desire to leave them behind forever? Then advance into the Corridor.

(Long pause. Usher removes blindfold in total darkness, while attendant gradually lightens moon by regulating rheostat.)

You are now turning your back forever upon superstition. Henceforth you are to be guided by scientific knowledge, that is, knowledge which is based upon verifiable personal experience, the experience of the five senses, for fact originates in sensory experience.

The great body of scientific knowledge which is freely available today is ours because men have unselfishly dedicated their lives to scientific service; because they have trained their senses, and have then placed them at the disposal of science; because they have used their trained faculties tirelessly in the search for truth. As you leave the domain of uncertainty and enter the realm of positive knowledge, trust ever the worthy testimony of your five senses.

(Light now dims, and blindfold is replaced.)

Go, and may your spirit nevermore quail at these remnants of the childhood of mankind.

(They pass to second attendant.)

Attendant: Who comes?

Usher: A candidate for admission to fellowship with the Alchemists who has left behind him the delusions of superstition and is ready to pass the Ordeal of the Five Senses.

Attendant: If there is fear in your breast, tarry without, for he who follows science must have a strong heart and an unflinching purpose.

Advance, Candidate, if you fear not the Ordeal of the Five Senses. You are now ready to undergo the Ordeal of Feeling. Take the hands that are offered to guide you and do exactly as you are told.

(Initiate takes the hands of two members who hold contacts connected with an induction coil. They lead him a few steps, giving a brisk shock. Another attendant places an "A" on the back of his hand with a moistened stick of silver nitrate. Usher stops him before a jar of ferric chloride solution.)

Usher: Now cleanse your right hand to receive the hand of fellowship.

(Removes blindfold, then replaces. Candidate shakes hand of attendant wearing rubber glove which is covered with dry tannic acid. They pass to third attendant.)

Attendant: You are now entering the Ordeal of Smell. Advance and remain absolutely motionless.

(While the initiate stands, beakers containing various liquids are held below his nose, such as hydrogen sulfide solution, ether, carbon disulfide, butyric acid, etc. They then pass to fourth attendant.)

Attendant: You enter now the Ordeal of Hearing which you must pass alone. Advance slowly straight before you.

(This may well be in a classroom, and the initiate be directed through an aisle, the seats on either side to guide him. The floor is thickly strewn with sizable dabs of dried nitrogen iodide on filter paper. The fusilade may be properly punctuated by potassium chlorate-sulfur torpedoes, wrapped in tinfoil and discharged between a hammer and brick. They pass to fifth attendant.)

Attendant: You are ready for the Ordeal of Taste. Stand motionless until you are instructed to move.

(The initiate is told to open his mouth and two one-half grain saccharin tablets are placed on his tongue. He must stand until they have dissolved in his mouth. They pass to sixth attendant.)

Attendant: The last ordeal, the Ordeal of Sight awaits you.

(The candidate is led in and placed before a static machine so that his eyes are exactly level with, and only a few inches from the contact points. Then as the crank is whirled rapidly, his blindfold is withdrawn. It is quickly replaced and he is next led to a stool where he is seated. Here he is instructed to look straight before him. An attendant lights a fuse of magnesium ribbon leading to a charge of potassium chlorate-powdered magnesium flash powder. As the ribbon ignites the candidate's blindfold is lifted. An amusing addition is to have a camera focused upon the candidate so that his picture is made as the flash is discharged. Later, these are interesting mementos of the evening.

Lastly, the initiate is placed in a small booth, formed by a screen, the three sides being covered with white Bristol board and lighted by a 200-watt lamp. The boards are covered with emblems of alchemy, while directly before the initiate is the club symbol. His blindfold is withdrawn for a few seconds, then

replaced. He is led to the last attendant, who may be the president of the club.)

Attendant: Who comes?

Usher: A candidate for admission to fellowship with the Alchemists who has left behind him the delusions of superstition and who has passed courageously the Ordeal of the Five Senses.

Attendant: Advance, Candidate. You have been thoroughly tested. You have manifested an interest in things scientific by applying for membership with the Alchemists. Your sincerity has been indicated by a high standard of scholarship. You have been approved by the Alchemists and received into fellowship by a unanimous vote. Your continued interest has been manifested by consistent attendance at our gatherings. You have expressed a willingness to forsake the puerility of superstition. You have passed the Ordeal of the Five Senses, symbolizing a new measure of truth—by sensory experience. You are now counted worthy to wear the emblem of the Alchemists, which stands, not as in the Dark Ages, for a selfish striving after personal wealth, but for the acquisition of scientific knowledge for the betterment and enrichment of mankind. May this ideal inspire you henceforth.

(Initiate is conducted to reception room.)

At the completion of each ceremony, the initiate is led to the reception room to await the others. When all have been led through, every one assembles here for games. One appropriate game is a modification of "Living Alphabets" in which two sets of placards, each bearing the symbol of an element are given to the players of opposite sides. The leader calls out the common name of a compound, such as "Rochelle Salt" while the players personating the elements involved line up to represent the formula. The side to form the correct formula first wins a point. A player holds up a given number of fingers to represent a subscript where necessary. The names must be planned beforehand, so that all placards issued may be used at least once, and none may occur twice in a formula.

Another diversion is a modification of an older game in which lines are formed by the two sides and a waste-basket full of apparatus given to each. At a signal, the objects are passed from one end of the line to the other. When all have been passed one way they are returned. The side replacing all apparatus first wins. The assortment includes such divers objects as combustion boats, pneumatic troughs, and a variety of sizes between, but the collections should be identical.

The artistic ability of the groups may be displayed by aniline dyes. A test-tube rack containing six or eight different solutions in test tubes is assigned to each side, together with a small brush, a beaker of water, and a large sheet of bristol board. Each side chooses an artist, who proceeds

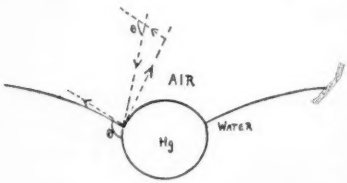
to fashion the best picture he can, with the advice of his fellows and the bright colors which are furnished. A prize is given for the cleverest picture.

Laboratory apparatus may be used in serving the refreshments. Beakers may be used for cocoa, evaporating dishes and porcelain spatulas for fruit salad, etc. The physics laboratory is generally suitable for serving the refreshments, providing ample table space without the objectionable odor of a chemistry laboratory. At the close, Bunsen burners may be attached for roasting marshmallows, using forceps or combustion spoons.

FLOATING MERCURY ON WATER

N. K. ADAM, THE UNIVERSITY, SHEFFIELD, ENGLAND

While trying, recently, a process for cleaning mercury, I obtained some small globules floating on water, in the same way that a waxed needle floats. The mercury had been shaken with sulfuric and chromic acids, and was finely subdivided; on pouring carefully into water, a few globules floated. Some of these ran together and coalesced in deep depressions in the surface; the largest floating globule was about 0.5 millimeter diameter. The flotation was quite stable, and was not destroyed even by contaminating the surface with a drop of oleic acid, which spreads to a film reducing the surface tension to about 46 dynes per centimeter. The accompanying rough sketch shows the directions of the relevant surface tensions dotted in.



The tensions of clean mercury against air (475 dynes per centimeter) and against water (375) differ by more than the surface tension of clean water, so that it would be impossible for clean mercury to float on water; the water would spread over the whole drop with zero contact angle. It is, however, well known not to be easy to get mercury clean enough for water to spread on it. The condition of flotation is that the contact angle, θ, should be definite, and for stable flotation it should be large. The mercury-air tension must be reduced to well within 46 dynes per centimeter of the mercury-water tension for flotation on the surface contaminated by oleic acid. Since the mercury had been emulsified in the mixed acids, probably even the mercury-water tension had been a good deal reduced; therefore, the mercury-air tension seems to have been reduced by an amount of the order one to two hundred dynes per centimeter. I have never seen a description of the floating of mercury and should be interested to hear if there is any record of it, or if any one else has observed it.— *Nature* (London), **123**, 413 (Mch. 16, 1929).

You don't have to preach honesty to men with creative purpose. Let a human being throw the energies of his soul into the making of something and the instinct of workmanship will take care of his honesty. . . . A genuine craftsman will not adulterate his product.—WALTER LIPPMAN

CHEMISTRY ON THE HIGH-SCHOOL STAGE

R. C. BERGEN, POINT PLEASANT BEACH HIGH SCHOOL, POINT PLEASANT, NEW JERSEY

Chemical experiments for use in short plays or special demonstrations by students on the stage must answer at least two requirements. They must be spectacular enough to be seen, and must be fairly easy of performance. The author in preparing a short play with a chemical background for the stage tried out and discarded many experiments before finally adopting the ones which were used. The ones ultimately selected proved quite successful for stage work and a short outline of the playlet may prove valuable to any one desiring to use some chemistry on the stage.

The experiments were worked up into a short play called "Fifteen Minutes in a Chemical Laboratory," participated in by two senior boys. The scenery represented a boy's amateur laboratory with several tables bearing considerable apparatus, and a small table, with books and papers, serving as a desk. A few chairs were also included. One boy was the owner of the laboratory and the other boy came to visit him while he was trying out some experiments. The owner goes on to show his friend some of the experiments he is working on and his visitor acts very timidly most of the time, thus furnishing the comedy element. A running dialog was written around the experiments and the timid friend furnished the laughs.

Outline of Experiments Used

1. Metallic magnesium lighted in spoon with a match; then thrown on pneumatic trough of water. Beautiful white flash.

2. Smoke in glasses. Used in form of trick. A few drops of HCl in one glass, and a few drops of ammonia in another. A piece of paper held in front and one glass placed on top of the other. Paper removed and both glasses found filled with smoke. (NH_4Cl.)

3. Spontaneous combustion. White phosphorus dissolved in carbon disulfide and poured on filter paper. In a few seconds the paper, hung up on a piece of wire, ignites itself.

4. Colored water experiment. A few drops of ammonia are added to a glass pitcher filled with water. In the first glass tumbler is placed a few drops of alcoholic phenolphthalein solution. In a second tumbler is placed a teaspoonful of dilute sulfuric acid. On pouring out the first glass it, of course, turns dark red immediately. Another one is poured into the acid, which stays uncolored. The boy visitor, however, says he is not thirsty now and the second glass is poured back. The amateur owner then walks away. The boy visitor has an idea that he will fix the pitcher of water so no one will drink it, whereupon he pours the

glass of red liquid back, expecting to color the pitcher red. To his surprise it turns colorless as fast as he pours it back, due to the acid now in the pitcher. The experiment is very simple and quite effective on the stage.

5. Burn a piece of picture wire in a jar of oxygen.

6. Burn a little powdered antimony in chlorine gas.

7. Four parts of ammonium chloride, four parts of zinc, and one part of ammonium nitrate. Mix well, place on iron pan, and ignite with a drop of water.

8. Red fire (light with 2- or 3-inch fuse)

1 part strontium nitrate
1 part sulfur
2 parts potassium nitrate
2 parts charcoal

9. Green fire (light with 2- or 3-inch fuse)

1 part sulfur
2 parts potassium nitrate
2 parts charcoal
2 parts zinc

10. Fire writing: Take one or more sheets of soft white typewriter paper and write with a concentrated solution of potassium nitrate, using a toothpick or match. The letters in the word or words must be connected. Allow to dry, and light at the first letter with a piece of Chinese punk, after fastening up against a dark background. It is effective to write the name of the school on two sheets and light them both at once. If large sheets of filter paper are available, these will work very well, but they should be at least eight inches by eleven inches.

Additional Comment on Experiments

The first experiment with metallic magnesium is particularly effective, is harmless, and very easy to perform. The magnesium burns slowly in the spoon with just a dull glow when lighted with a match. Do not use over one-half tablespoonful, preferably one-third. Allow the magnesium to burn practically out before throwing it on the water.

It is effective to pretend to blow the smoke from a lighted match into the glasses through the paper in Experiment 2.

In Experiment 4 it is effective, of course, to have the visiting boy ask for a drink.

Experiments 5 and 6 are well known and require no explanation.

Experiments 8 and 9 were contained in small iron pans. If possible, keep them toward the back of the stage as they make considerable smoke. Fuses can be made by soaking cotton string in potassium nitrate.

In Experiment 10 use the solution hot when writing on the paper, but not so concentrated that it will not soak through the paper. An additional comedy situation was inserted by the author in the form of a large imitation paper fire cracker lighted by an explosive match, but this was not necessary to the success of the play.

It is advisable to have a small fire extinguisher handy in case of emergency.

Conclusion

The experiments mentioned are spectacular, easy to perform, require very little apparatus, no gas burner, only a box of matches and a piece of punk for igniting, and because of their showy nature and simplicity are well adapted for stage work.

WHY DOES A SUBSTANCE BURN?

K. M. PERSING, GLENVILLE HIGH SCHOOL, CLEVELAND, OHIO

Bring the flame of a lighted match into contact with some paper, fine wood shavings, or splints. Notice the speed with which the substance begins to burn. Can you suggest a reason for the substance igniting? Is there a possibility that fire is transferred from the burning match to the paper or wood?

The purpose of this experiment is to help you answer the questions given above. Follow the next part of the work and see if you can answer the questions.

Support a piece of sheet metal of good size, approximately 10 inches square, on a tripod. This sheet metal may be provided either by cutting open an ordinary gallon can or using a pie pan such as may be secured at the 10-cent store. Place a Bunsen burner with a well-adjusted flame under the sheet metal. Use a good-sized flame, being careful that the flame does not play over the edges of the sheet metal. Now place wood splints or fine shavings on the sheet metal directly above the flame of the burner. In a short time the wood shavings will begin to glow and then burst into flames.

You must remember that the flame has not been permitted to come into contact with the combustible substance.

How do you explain the cause of combustion?

When does a substance begin to burn?—*Neo-Chemto-Ion*, **3**, 12 (Feb., 1929).

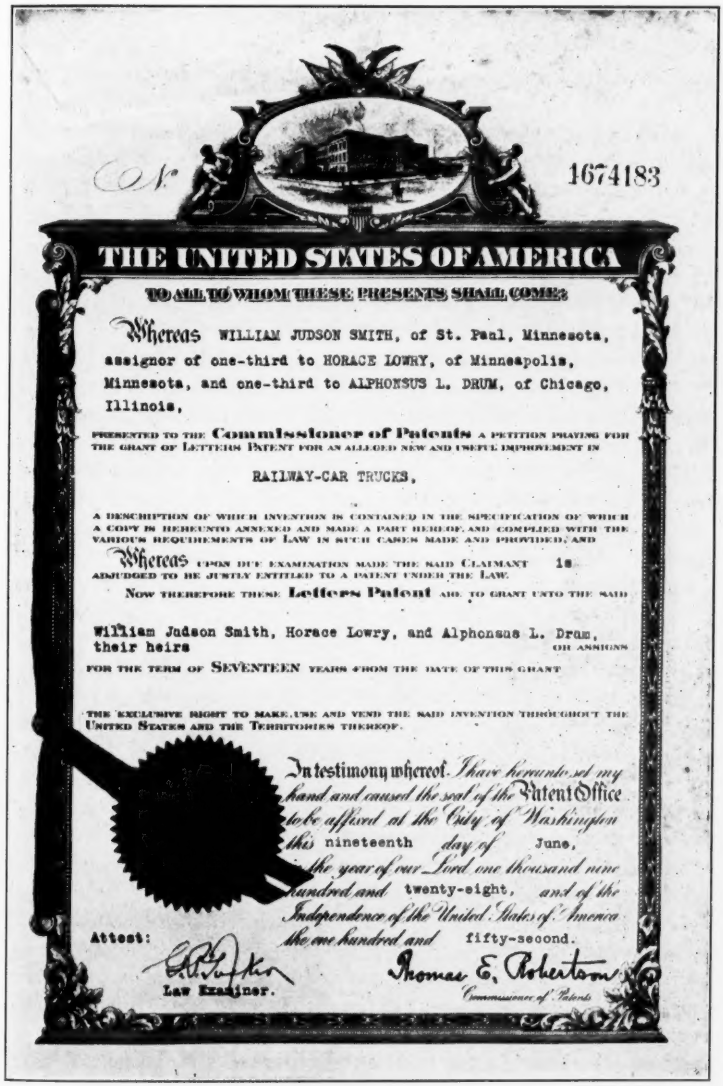
WHAT THE CHEMISTRY STUDENT SHOULD KNOW ABOUT PATENT PROCEDURE. III. PREPARATION OF THE APPLICATION

LLOYD VAN DOREN, WARFIELD & WATSON, 247 PARK AVENUE, NEW YORK CITY

The question naturally arises as to what may be patented. This question is best answered by turning to the Patent Statutes.

The statutes set forth that a patent may be obtained for a new and useful art or machine or manufacture or composition of matter or any improvements thereof which may be new and useful, providing the following conditions pertain: that there is no prior patent; that there is no published description either in this or a foreign country; that it was not known or used by others in the United States; that it has not been in public use or on sale in the United States for more than two years before filing the application, unless it should have been abandoned. Further, the statutes set forth that the grant of a patent will not be barred nor will a patent be declared invalid because a patent was first taken out in a foreign country unless the application on which the foreign patent is granted was filed more than twelve months before the application is filed in the United States. If the foreign application was filed more than twelve months before filing here, a patent will not be granted. If an application is filed within twelve months of filing the foreign application, the application then will have the same force and effect that it would have, had it been filed here on the same day that it was filed abroad. This last provision is what is usually termed the International Convention, to which most of the leading countries of Europe, as well as countries in other parts of the world, are parties, and the main benefit, so far as the filing of foreign applications is concerned, is the twelve months' priority period. This may be summed up with respect to an applicant having filed an application in our Patent Office, in that he is allowed a twelve-month period within which he may file applications for patent in foreign countries. If he files under the International Convention, he is awarded the date of his United States application for priority purposes and is thereby protected from publication or prior use which may take place between the time that he files his United States application and that at which he files his foreign application. This protection is very valuable in cases where the invention has been published or gone into public use almost immediately after the application has been filed.

By way of illustrating somewhat more concretely that which may constitute patentable subject matter, it may be considered that there is in practice a process for making naphthalene disulfonic acids which requires the steps *A*, *B*, *C*, *D*, and *E*. One working in the laboratory finds that he may prepare these acids by a process which requires but three of



No. 1674183

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas WILLIAM JUDSON SMITH, of St. Paul, Minnesota, assignor of one-third to HORACE LOWRY, of Minneapolis, Minnesota, and one-third to ALPHONSUS L. DRUM, of Chicago, Illinois,

PRESENTED TO THE **Commissioner of Patents** A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL IMPROVEMENT IN

RAILWAY-CAR TRUCKS,

A DESCRIPTION OF WHICH INVENTION IS CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND COMPLIED WITH THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED; AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANT is ADJUDGED TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

NOW THEREFORE THESE **Letters Patent** ARE TO GRANT UNTO THE SAID

William Judson Smith, Horace Lowry, and Alphonsus L. Drum, their heirs OR ASSIGNS

FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT

THE EXCLUSIVE RIGHT TO MAKE, USE AND VEND THE SAID INVENTION THROUGHOUT THE UNITED STATES AND THE TERRITORIES THEREOF.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this nineteenth day of June, in the year of our Lord one thousand nine hundred and twenty-eight, and of the Independence of the United States of America the one hundred and fifty-second.

Attest:

Law Examiner.

Thomas E. Robertson
Commissioner of Patents.

FACSIMILE OF A UNITED STATES LETTERS PATENT GRANT

the five steps or, let us say, the steps *A*, *C*, and *E*. This new process would be an improvement over the older process and should be patentable.

Instance may also be made in the field of high-boiling esters. Assuming that the alkyl esters of phthalic acid were known and it should be discovered that by using the same process there could be obtained esters using dihydric alcohols such as ethylene glycol, the process here could not be patented in as much as it was previously well known, but the new compounds could be protected. In the field of indigoid vat dyes, it was known that two molecules of a substituted thionaphthene could be linked to form a symmetrical indigoid vat dye. It was subsequently discovered that new vat dyes would result when unsymmetrically substituted molecules or a thionaphthene were caused to react. The process and product in the latter case received patent protection.

The first step that must be taken to obtain a patent is that the inventor must prepare or have prepared an application for letters patent and forward it to the Commissioner of Patents. This application must contain a written description of his invention and of the manner and process of making, constructing, compounding, and using it, and it must be in such full, clear, concise, and exact terms as to enable any person skilled in the art of science to which it appertains, or with which it is most nearly connected, to use the invention so that it may be distinguished from other inventions, and he must also particularly point out and distinctly claim the improvement or combination which he considers his invention or discovery. The application consists of three parts.

First, there is the petition which usually carries a power of attorney, and in which the inventor asks that he be granted a patent for his alleged invention.

The second part in turn consists of two parts, namely, the specification and the claims. The specification sets forth the art to which the invention pertains; the objects accomplished by the invention; a general description of the invention including illustrative embodiments of a manner in which it may be carried into practice, these embodiments or illustrations presenting the way considered by the inventor as the best for practicing his invention. Then the specification may close with a presentation of the properties or effects produced by the invention and the applications which may be made of it.

Unfortunately, it is sometimes assumed by an inventor and sometimes by his attorney that the drafting of the specification and claims is a matter of comparatively minor importance. It seems that the unsoundness of this assumption must be apparent at once, for the strength of any patent depends solely upon the manner in which the specification and claims are drawn and the care which has been given to the work of their drafting. Unless the specification and claims are commensurate and properly describe and set forth the invention, they do not properly support a patent, because the invention of any patentee is theoretically that which he

discloses and the specification and claims constitute this disclosure. The specification and claims must be considered together, for the infringement of a patent depends upon the claims, but no worker would know how to use the invention by simply reading the claims. It may be said also that the stronger the patent, the less likely is it to become a matter of litigation, whereas the reverse is equally true, that the weaker the patent, the more likely is it to become a matter for litigation.

It has frequently been said that chemical patents differ materially from mechanical patents. Mechanical patents, however, constitute the majority of patents granted, the chemical patents granted being much smaller in number. While the discrepancy now is not as marked as it was ten to fifteen years ago, the difference is, however, still a very noticeable one. The main difference between mechanical patents and chemical patents resides in the fact that a mechanical patent has to do with something which is tangible, for example, a machine. If such a patent is before a court, it is quite possible for the court to look at the drawings or perhaps even at a model of the machine and be able to satisfy itself from its examination that that is the machine called for and described in the patent, and that it will operate. In short, something tangible can be presented. On the other hand, in the case of a chemical patent which deals, for example, with a process for making anthraquinone, the court is not able from a drawing or even from a demonstration in the court room to visualize directly the operativeness of that process. It is something which is intangible. Accordingly, chemical patents must be drawn with even greater care than must be exercised in the drafting of mechanical patents. It is hoped, of course, that it will never be necessary to litigate a patent, but every one knows that this frequently happens, so the drafting of the specification and claims must be done with that possibility in mind. It must be drafted in such terms as are usual in the art, but also in language which may be readily grasped by a court and in terms which are unambiguous. The courts consider the drafting of a specification for a patent (which is a legal document, in the nature of a contract) as one of the most difficult instruments to draw. For example, in the case of Topliff vs. Topliff, the court on this point made the following statement:

> The specification and claims of a patent, particularly if the invention be at all complicated, constitute one of the most difficult legal instruments to draw with accuracy, and in view of the fact that valuable inventions are often placed in the hands of inexperienced persons to prepare such specifications and claims, it is no matter of surprise that the latter frequently fail to describe with requisite certainty the exact invention of the patentee, an error either in claiming that which the patentee had not in fact invented, or in omitting some element which was a valuable or essential part of his actual invention.

Along this same line, the Court, in the case of Westinghouse Electric &

Manufacturing Company against the Metropolitan Electric Manufacturing Company, set forth that:

> What any patentee has invented is theoretical; what he discloses, and the disclosure, is the specification. A claim is a definition of that which has been described in the specification. Theoretically, the "man skilled in the art" knows how to do what the inventor did when he has perused the disclosure. When one infringes a patent primarily depends, to be sure, upon consideration of the claims; but no man would know how to practice the invention by reading the claims. A claim not supported by the specification is a bad claim. A disclosure which tells how to do a thing not claimed is a misfortune for the patentee.

The second part, or claims, is the more important part of the specification, for it is upon these entirely that the protection rests. It is frequently the practice, and perhaps the better practice in preparing the specification and claims, to draft the claims first, as thereby the scope of the invention will have been fully worked out and the phraseology determined upon, so that when the specification is drafted the same phraseology will appear and the scope thereof be wholly commensurate with the scope of the claims. This is extremely important, as otherwise the claims may define the invention more broadly than the description in the specification warrants and hence the claims are open to rejection on the ground that they are not properly supported in the specification, and on the other hand the claims may be too narrow, so that the inventor does not receive the full protection to which he is entitled, and it might also happen in this case that more than one invention is disclosed in the specification, whereas only one is claimed. If this should happen, the inventor would be protected only as to the one invention, and the public would be free to use the other without any compensation to the inventor.

When the claims are improperly drawn and consequently defective, either through misunderstanding or lack of comprehension of the invention by the attorney, or through incompetence or negligence, the inventor cannot look for a remedy of the defects by the courts. As illustrating this, a portion of the opinion in the Keystone Bridge Company vs. Phoenix Iron Company may be cited:

> Since the Act of 1836, the patent laws require that an applicant for a patent shall not only, by a specification in writing, fully explain his invention, but that he shall particularly specify and point out the part, improvement or combination which he claims as his own invention or discovery. This provision was inserted in the law for the purpose of relieving the courts from the duty of ascertaining the exact invention of the patentee by inference and conjecture, derived from a laborious examination of previous inventions, and a comparison thereof with that claimed by him. The duty is now cast upon the Patent Office. There his claim is, or is supposed to be, examined, scrutinized, limited and made to conform to what he is entitled to. If the Office refuses to allow him all that he asks, he has an appeal. But the courts have no right to enlarge a patent beyond the scope of its claim as allowed by the Patent Office, or the

appellate tribunal to which contested applications are referred. When the terms of a claim in a patent are clear and distinct, as they always should be, the patentee, in a suit brought upon the patent, is bound by it. Merrill vs. Yoemans, 94 U. S. 573. He can claim nothing beyond it. But the defendant may at all times, under proper pleadings, resort to prior use and the general history of the art to assail the validity of a patent or to restrain its construction. The door is then opened to the plaintiff to resort to the same kind of evidence in rebuttal; but he can never go beyond his claim. As patents are procured *ex parte*, the public is not bound by them, but the patentees are. And the latter cannot show that their invention is broader than the terms of their claim; or, if broader, they must be held to have surrendered the surplus to the public.

In as much as the claims constitute the part of the patent upon which protection rests and which is relied upon for charges of infringement, it is quite possible for persons knowing what the claims of a patent are to avoid infringing the patent and use everything disclosed in the patent that is not claimed therein, unless the claims are wholly commensurate with that which is disclosed in the specification. Accordingly, in the drafting of the specification and claims, or in fact in the consideration of the invention, the work of the inventor must be wholly analyzed so that the invention may be properly claimed and avoid as far as possible all of the following probabilities:

First, that the same idea may be taken and a real improvement or development made thereon. It may be that the new improvement possesses patentable novelty. The claims should be so drawn as to cover this probability for, even though the improvement may be patentable, nevertheless, it will be dominated by the claims of the patent, and hence the later patentee will be unable to use it until the expiration of the first patent.

Second, there may be worked out an alternative idea which may give results equally good and would constitute a real competitive factor for the invention described in the patent. While it is not possible to claim alternatives in a single patent, in this event, knowing of the alternative procedure, a patent should be taken out for it.

In the third place an attempt may be made to evade the patent by a worker who will conduct his work so that it falls without the claims of the patent, giving results which are not as good as the process covered by the claim, but sufficiently good to enable him to work on a competitive basis. The claims should accordingly be of sufficient breadth to cover this probability.

It is therefore of the greatest importance that the claims be most carefully drafted and for the further reason that in the event of a suit for infringement the whole protection lies within the claims. If they are poorly drawn the inventor may have a patent only and no protection.

The third part of the application is the oath which the statute provides shall set forth that the inventor verily believes himself to be the original

and the first inventor or discoverer of the art, machine, manufacture, composition, or improvement for which he solicits a patent, and that he does not know and does not believe that his invention was ever known or used before his invention or discovery. Further, that to the best of his knowledge and belief the invention has not been in public use or on sale in the United States for more than two years prior to his application or patented or described in any printed publication in any country before his invention, or more than two years prior to his application or patented in any foreign country on an application filed more than twelve months previous to his application here. He must also give the country of which he is a citizen, the place where he resides, and whether he is a sole or a joint inventor.

The application shall also contain a drawing whenever the nature of the invention admits. The Patent Office sets forth rather detailed instructions as to the preparation of these drawings, which instructions should be wholly followed by the draftsman. It is not necessary that the drawings be prepared by the Patent Office. Any competent draftsman may do the work, but the Patent Office will do so if requested by the inventor.

CHEMISTRY

MILDRED WATSON, ORANGE UNION HIGH SCHOOL, ORANGE, CALIFORNIA

Mixtures, elements, compounds, Oh!
Valence I will never know.
Equations, now, are not so bad,
Once the formula is had.
As for problems, Oh, gee whiz—
How I hate them in a quiz!
Unknowns remain unknown to me;
A chemist I fear I'll never be.
Anodes and cathodes, electrons and such
Seem quite determined to get me in Dutch.
Acids and bases and gases and salts
Can't seem to stay in my memory's vaults.
The money I've lost in equipment, oh dear,
Will keep the school running for many a year.
And yet, tho' I'll flunk the course, sure as fate,
I'll have to admit I think chemistry's great.

When men are rightly occupied, their amusement grows out of their work, as the color petals out of a fruitful flower; when they are faithfully helpful and compassionate, all their emotions are steady, deep, perpetual, and vivifying to the soul as is the natural pulse to the body.—JOHN RUSKIN

JUSTUS VON LIEBIG: THE SPONSOR OF A PRIZE CONTEST IN CHEMISTRY

ERNEST R. SCHIERZ, UNIVERSITY OF WYOMING, LARAMIE, WYOMING

We have long been accustomed to associate the name of Liebig with important discoveries, with the introduction of new methods and new viewpoints in chemistry, and perhaps we may now look upon him, also, as a pioneer of prize contests in this science. Among his papers and letters[1] are several pertaining to a prize contest. There are an announcement of the contest in final form as well as a preliminary draft; a set of questions; a draft of an address to be made upon presentation of the prizes; and a list of names, some of them autographs. The announcement is on a sheet of legal size paper yellow with age, and the paste still adhering along the edges of the reverse side gives evidence that it may have been posted. We may ask ourselves the question—"Where?"—but we must supply our own answers. Perhaps it was at the entrance to the lecture room or even in the laboratory. The announcement is here reproduced in facsimile. A translation of it follows.

Although chemistry, more than any other science, assures those who pursue its study with eagerness, with a thankful reward, through the distinct usefulness of its knowledge, I have decided to confirm the recognition of the exceptional industry of my present students in an unusual way.

During one of the closing days of this course I shall invite my pupils to meet some afternoon.

I shall place before them 30 questions covering the field of the science discussed in the lectures.

I will ask them to answer these questions in writing.

Every set of answers is to be identified by a motto. The name of the contestant is to be placed in an envelope, and sealed; the envelope to bear on its outside the same motto.

Every question will be given a number, the magnitude of which will indicate the difficulty of the question.

Those who give the most nearly correct answers, which will be determined by the sum of the numbers of the correctly answered questions, will be awarded two prizes which will be presented at the following lecture.

The first prize is a chemical knife[2] with a platinum blade and palladium and silver mountings.

The second prize is a chemical lamp.

Should it occur, and this is not improbable, that several should get the same rating on these 30 questions, the awarding of the prizes will be determined by the answers given to a further set of 3 or 4 questions.

Dr. Just. Liebig

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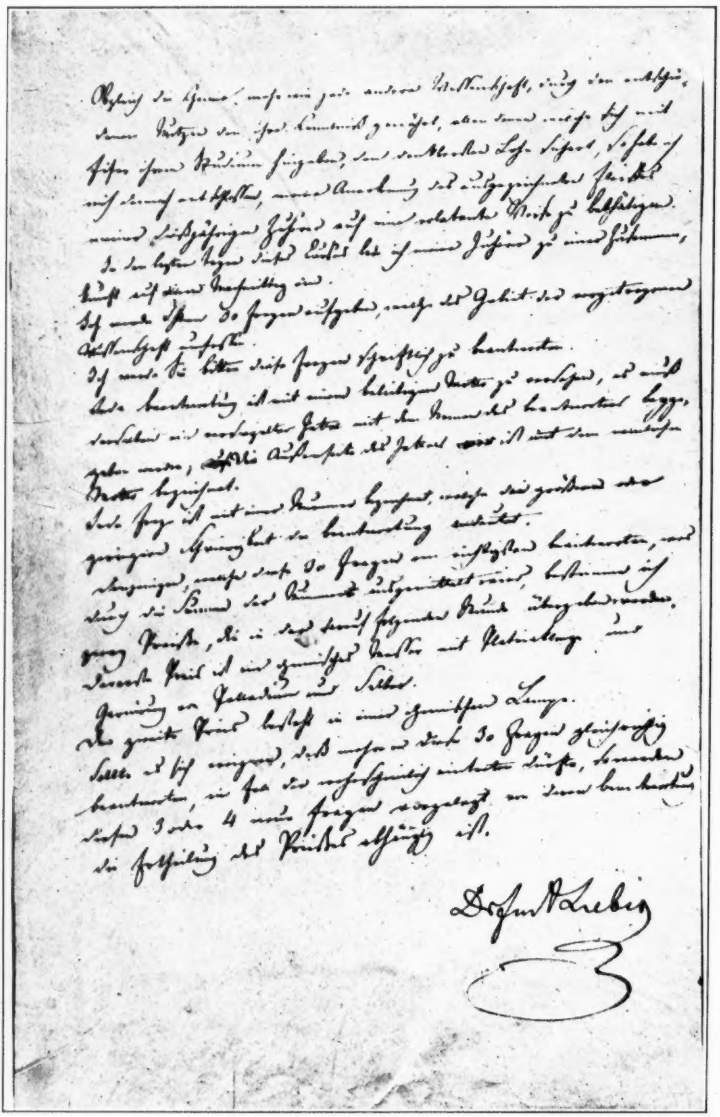
[1] Since April 22, 1922, these personal archives have been open to the public without restriction. They are to be found in the Bayerische Staatsbibliothek München, Handschriften Abteilung (Munich, Germany).

[2] Spatula?



THE ANNOUNCEMENT OF LIEBIG'S PRIZE CONTEST IN HIS OWN HANDWRITING

We can only conjecture with what comments his students greeted this announcement. Were they enthusiastic about it, did many signify their intentions of participating? Is the list of names the list of those who elected to take part in the examination? There are no notations on the list, however, which would associate it with the contest.

Let us examine the questions. We can probably accept them as giving a fair picture of the state of chemical knowledge of the time, for the lectures of Liebig who was taking such an active part in the development of chemistry certainly kept pace with the advancements of the science. The draft of the questions seems to be just a memorandum, and was probably written at the time the announcement was conceived, for the same blue-grey paper is used. It is incomplete, there are in it only 21 questions. Their translation was accompanied by difficulties due to poor legibility of some of the words. Where words have been omitted this fact is indicated by ———; where the translation is doubtful the word is followed by (?)

What is the atomic weight of a simple, a compound and——material?

1. What is oxygen, how is it prepared, what are its most important properties?
2. How is phosphorus prepared, what are its most important compounds, what changes does phosphoric acid undergo when ignited?
3. How is chlorine prepared; what are its important properties and compounds?
4. The properties of the most important compound of carbon and oxygen? What is its composition?
6.[3] How is oxygen determined in atmospheric air? Of what is it (air) composed? How is the constant oxygen content explained?
7. What is the composition of nitric acid, how is it prepared, what occurs when it is heated with organic substances, sugar, starch, etc.?
8. How does nitric oxide react with oxygen? How is nitrous acid (?) decomposed when brought in contact with water?
9. What is alcohol? How is it prepared?
10. How is ethylsulfuric acid formed and what is its composition?
11. What is the composition of ether, how is it prepared, in what manner is it formed?
12. What are the compound ethers,[4] how are acetic ether and oxalic ether prepared?
13. How are compound ethers decomposed by water and alkalies?
14. How does oxalic ether react with ammonia?
15. What is aldehyde, how is it prepared?
16. How does acetic acid form from alcohol?
17. What is an "oxy-acid?" What are the most important oxy-acids, how do they react with metallic oxides?
18. How is prussic acid—hydrocyanic acid—prepared?
19. What is the composition of ammonia, what viewpoint brings the composition of the ammonia salts in agreement with the composition of salts whose (?) bases (?) are metallic oxides?
20. —— —— —— —— —— barium oxide and its important compounds?

[3] The numbering follows the manuscript.

[4] "Compound ether" was the name given to esters at that time.

22.[5] What are the harmful gases which form in —— —— ——? What means are employed to destroy them?

These papers are not dated, but from question 15—*What is aldehyde, how is it prepared?*—we know that they were not written before 1835. It was in this year that Liebig announced the isolation of the compound for which he coined the word *aldehyde*.[6]

The names of the winners are not recorded, but from the draft for a "Criticism of the Examination and Awarding of the Prizes," the following quotation indicates that the Professor was delighted by the performance of his pupils. "I must admit that the answers filled me with pride. I am proud to have trained such pupils. They are documents that my innermost efforts have borne fruit. It was difficult for me to make a choice from among so many worthy papers, but it was necessary. . . . . "

When we recall that examinations at the conclusion of a course of lectures were very unusual, in fact almost unknown, at this period we can appreciate the novelty of this contest and its appeal to the students.

[5] The numbering follows the manuscript.

[6] *Liebig's Ann.*, **14,** 133 (1835).

THE OXIDATION OF ZINC—A DEMONSTRATION

MARTIN MEYER, THE COLLEGE OF THE CITY OF NEW YORK, NEW YORK CITY

Mr. Louis Tuchfeld, one of our students in inorganic chemistry, has just discovered an interesting reaction which is, so far as I have been able to determine, new, and which as a lecture experiment illustrates excellently well the oxidation of zinc and the principle of spontaneous combustion. It seems worthy of record.

A mixture of 9 parts by weight of ammonium nitrate and one to two parts of ammonium chloride is placed in a shallow layer in a tin sand-bath or other appropriate dish. One spreads on top a thin layer of finely powdered zinc. A drop of water placed on top of the zinc (*e. g.*, with an eye-dropper) causes the mixture, after a moment or two, to take fire with the evolution of dense clouds of zinc oxide.

Soap Speeds Your Auto. Many tons of soap are used every year where people least suspect it—as a thickening agent in the grease in the gears and lubricating systems of automobiles. Otherwise, it would not be possible to apply petroleum lubricants to these places, and we would have to go back to fats, which were the first lubricants for machinery.—*Chem. & You*, **6,** 2 (1929).

Chemical Digest

THE ADVICE OF ALBERTUS MAGNUS TO THE AMBITIOUS ALCHEMIST

Even though we have advanced far since the days of the alchemist, the advice contained in the following article by Tenney L. Davis in The Nucleus, February, 1929, might be profitably heeded by our 20th century chemists.

Albertus Magnus (1193–1280), eldest son of the Count of Bolstädt, was Provincial of Dominicans in Germany from 1254 to 1257 and Bishop of Ratisbon from 1260 to 1262, but resigned both of these positions, evidently because he preferred to devote himself more fully to his studies. He was the most prolific of the writers of the thirteenth century, the most influential of its teachers, and the dean of its scholars. It was natural that he should write on alchemy. His writings show that he had the real experimentalist's acquaintance with his subject matter.

His treatise *De Alchemia* describes the common metals, and a considerable number of chemical substances for the preparation of which it gives workable directions. It describes clearly the construction of furnaces proper for the various operations, and details the steps in the glazing of earthenware vessels. The author was undoubtedly acquainted with his materials at first hand. There is also considerable evidence which indicates that he was well read in the earlier Arabic works on alchemy. His language in places is so similar to that of the Latin Geber that it seems evident that the two authors had access to the same original. His admonition to the student desirous of undertaking alchemical experimentation is strikingly similar to that which Jabir ibn Hayyan (the Arab Geber) gave to his disciples in the eighth century. The advice here translated from thirteenth century Latin is therefore, in its main points, at least twelve centuries old. It appears that much of it is still good.

"The first precept then is that the worker in this art should be silent and secret, and should reveal his secret to no one, that he should offer nothing further in the way of explanation, knowing for certain that if many know he will accomplish nothing which is not divulged, and, when it shall have been divulged, it will be reputed a forgery—and so will be in perdition, and the work will remain imperfect.

"The second precept is that the worker should have a place and a special house away from the sight of men, in which there are two or three arches in which the operations of subliming and of making solutions and distillations are carried on, as I will teach later.

"The third is that he should observe the time in which the operation is to be performed and the proper hours for sublimations, solutions, and distillations—for sublimations do not succeed in the winter time while solutions and distillation may be made at all times. I will, however, teach clearly all these points about the operations.

"The fourth is that the worker in this art should be sedulous and frequent in his operations, and should not tire, but should persevere to the end. Because, if he should begin and should not persevere, both time and substance would be lost.

"Fifth, that he should work according to the institution of the art; first in contritions, second in sublimations, third in fixations, fourth in calcinations, fifth in solutions, sixth in distillations, seventh in coagulations, and so in order. If, however, he should wish to tincture before sublimation, and to coagulate and dissolve by means of distillation, he will lose his powders, because, when they shall have been projected, they will very quickly fly away and he will not retain anything from them. Or, if he should wish to tincture with fixed powders which have not been dissolved or distilled, such powders do not incorporate or mix with substances.

"The sixth is that all vessels in which medicines may be put, whether water or oil, whether over the fire or not, ought to be of glass or glazed. For if acute waters are put in a copper vessel, they produce green substances from it; if in one of iron or lead, they are blackened and contaminated; if in one of earthenware, they will penetrate it and all will be destroyed.

"The seventh is that you ought to beware before all else of involving yourself with princes or potentates in any operation, because of two evils—for, if you have involved yourself, they inquire after you from time to time and say, "Master, how do you succeed? When shall we see something good?" and, not being able to wait for the end of the work, they say that it is nothing, that it is *truffa*, etc., and then you will have the greatest of annoyance. And if you have not obtained a good result, you acquire everlasting indignation from it. If, however, you have obtained a good result, they think to detain you forever and will not allow you to go away and so you will be ensnared by the words of your own mouth and entangled by your own speeches.

"The eighth precept is that no one ought to involve himself in these operations who has not abundant funds, at least enough to be able to provide all things which are necessary for the art and in fact all which are useful. And if he has involved himself and funds lack, then the wherewithal and all else is lost."

ANCIENT SYMBOLS FOR METALS

*The following letter of interest from J. White of Bec School, London, appeared in Science Progress, **23**, 687 (Apr., 1929).*

"DEAR SIR,—A short while ago I was much impressed by the marked similarity between our present numerals and the ancient symbols for the metals.

"I give below the symbols, transcribed as faithfully as possible, from Campbell Brown's *History of Chemistry*, and the figures I derive from them.

☉	☾	♀	♂	♃	♄	♁	☿
Gold (Sun)	Silver (Moon)	Copper (Venus)	Iron (Mars)	Tin (Jupiter)	Lead (Saturn)	Antimony	Mercury
0	1	2	3	4	5	6	7

8 and 9 could be made by starting the rows again in twos as ☉☉ ☉☾.

"I at once began to see if this order could be justified by any sequence common of old, such as the planets which ruled the days of the week, the order of value, use or rarity of the metals, etc., but so far I have found none.

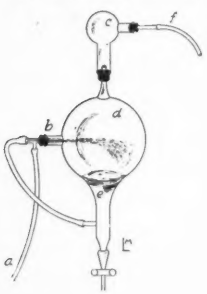
"Of course, I am well aware that our numerals are usually regarded as of Arabian origin, but there is much indefiniteness in the matter. Also, I know of the commonly accepted origins of the symbols, such as the caduceus of Mercury, the looking-glass of Venus, the shield and spear of Mars, etc., origins which were I believe first tentatively offered by M. Berthelot in his *Introduction à l'Étude de la Chemie des Anciens et au Moyen Âge*. But for all this I cannot help feeling that the resemblances, especially in the case of two or three, are too marked to be accidental, and at least I hope that the matter may provide interest or amusement or both to the readers of your worthy journal."

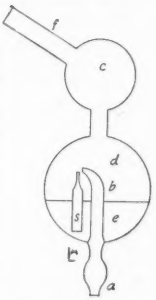
Recent Report of U. S. Bureau of Standards. According to the annual report of the U. S. Bureau of Standards for the year ending June, 1928 (Washington, D. C.: Government Printing Office, 5 cents), the work of the Bureau has been divided into two groups, the first dealing with scientific research and testing, the maintenance of standards and their improvement, the second with the supervision of commercial standards with special reference to the needs of industry. The regular staff now numbers 860, and the salaries 572 thousand dollars per annum. The fee values of the tests carried out by the Bureau were: for the public, 67 thousand dollars; for the Government and States, 351 thousand dollars; and for the Bureau, exclusive of research and standardization tests, 46 thousand dollars. Upkeep of the buildings, plant, and grounds has cost 83 thousand dollars and additions 88 thousand dollars. The work done is summarized under various headings, the total cost of each group is stated, and ten or a dozen lines are devoted to a description of each research of the group.—*Nature* (London), **123**, 468 (Mch. 23, 1929).

ABSTRACTS

TEACHING METHODS, AIDS, APPARATUS, AND SUGGESTIONS

An Apparatus for Obtaining Fine Dust for Coloring Flames. H. EMDE. *Chem.-Ztg.*, **53,** 1003 (Dec. 26, 1928).—According to authorities the atomizer made by Gouy (Figure 1) is the best arrangement for obtaining colored flames. *b* is a nozzle consisting of two concentric tubes sharply constricted. *a* stream of air comes through *a* causing suction in the center tube which is connected to a supply of salt solution and the salt solution is thus sprayed into the bulb *d*. The larger drops fall back into the main portion of the solution while the finer ones are carried into *c* where a further separation takes place so that only the very finest particles are carried through *f* into the burner.



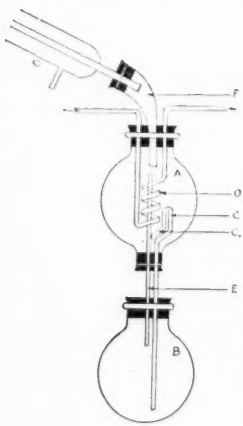


This simple type apparatus has been improved by making it entirely of glass (Figure 2). An angular atomizer *s-b* is sealed into the bulb *d* and connected to a source of air-pressure (60 cm. of water is quite sufficient). *d* is sealed to a smaller vessel *c* serving the same purpose as in Figure 1. Very fine particles are discharged through *f*, which may be connected by a small rubber tube to the openings at the base of a burner so adjusted as to allow a rich admixture of air. The vessel is charged through *f* in such a way that the suction tube *s* dips into the solution but that the solution does not reach the horizontal level where *s* and *b* are connected.

The apparatus may be used for qualitative analysis as well as for demonstration purposes.

C. E. M.

A Useful Intermittent Extraction Apparatus. C. W. EDDY. *Chem.-Analyst*, **18,** 16 (Jan. 1, 1929).—The extraction apparatus, shown in the accompanying diagram, in addition to requiring a small amount of solvent, can be used for both distillation and extraction.



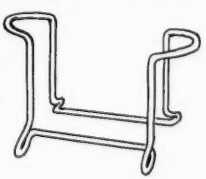
Flask *A* is an ordinary ring neck, round-bottom, 1-liter pyrex flask, having sealed in directly beneath the mouth of the flask a 4 cm. length of 20-mm. pyrex tubing. For distillation, the lower hole is closed with a solid stopper. For extraction, the solid stopper is replaced by a stopper containing the siphon tube *C*, and the vapor tube *E*. The height of *C* will necessarily depend upon the amount of solvent required to cover residue in *A*. A small extraction cone should be placed around tube C_1, to prevent residue from being sucked over into flask *B*.

"The cooling coil *D* can be made by heating ordinary glass tubing in a wing-top flame and feeding it around a carbon electrode $1^1/_2$ cm. in diameter. The diameter of the coil depends upon the size of the mouth in the flask *A*. *F* is an adapter forming a connection between the flask *A* and the condenser *G*.

"The entire apparatus can be made and assembled in about an hour and a half."

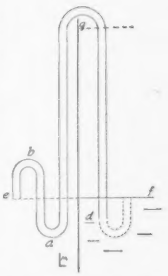
M. W. G.

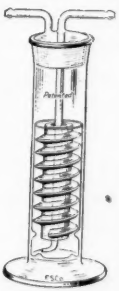
A Weighing Stand for U-Tubes. (D. R. G. M. No. 1,049,367.) G. PIATKIEWICZ. *Chem.-Ztg.*, **52,** 842 (Oct. 27, 1928).—This weighing stand allows a convenient and accurate weighing of calcium chloride and drying tubes in a vertical position. In absorption processes neighboring U-tubes may remain connected during the weighing. This device avoids the use of



wire for hanging the tubes when weighing and may also be used for keeping the U-tubes when not in use. C. E. M.

A Practical Siphon. P. FUCHS. *Chem.-Ztg.*, **53,** 90 (Jan. 9, 1929).—A siphon which will continue to function with changing level of liquid may be made very easily from one piece of glass. This is demonstrated by the accompanying diagram showing an ordinary siphon with a bent neck, *a b e, b* serving to direct the stream of water downward. The other end of the siphon lies between *a* and *b* in height. The level of the liquid in the vessel will fall to *e* and the siphon will no longer operate while *d* remains below the surface of the liquid and so the siphon remains ready for operation. Even if the level falls below *d* the siphon will not empty provided the tubing is narrow. If the tube is too wide or the liquid of low surface tension, the tube may be bent up as shown by the dotted lines; *e* and *f* need not be on exactly the same level. The tube is most easily filled by holding the opening in a rapid stream of water (best obtained by injecting it within the faucet) and then slowly withdrawing it. If the vessel is full, a previous filling of the siphon is unnecessary. To start siphon, simply close *e* and plunge the other end into the liquid. Then open *e* suddenly and the liquid will be given a sufficiently hard pull to overflow the level *g* and the siphon will automatically begin operation. C. E. M.

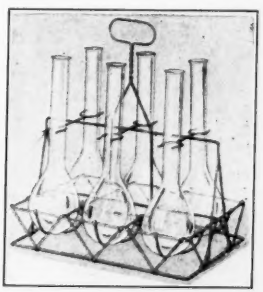




The Milligan Gas Washing Bottle. *Laboratory*, **2,** 31 (1929).—"In the Milligan bottle small bubbles travel eight times around the spiral, a distance of 43 inches, yet the entire bottle is but 9 inches high. A three-inch settling chamber at the top permits mechanically entrained liquid to settle. In this way, a gas absorption is effected which is equivalent to that heretofore obtained with a battery of 5 of the old style bottles.

"The glass spiral is hollow and open at both ends. The travel of the bubbles around the outside of the spiral creates a complete circulation of the absorbing liquid, upward on the outside of the spiral and downward inside the spiral.

"All parts of the Milligan bottle are removable so that it can be effectively cleaned and refilled. The spiral is made of molded glass and is not fragile. The Milligan bottle is made in a glass-stoppered and also a rubber-stoppered style." G. B. C.



A Portable Rack for Kjeldahl Flasks. *Laboratory*, **2,** 23 (1929).—"A convenient rack for holding Kjeldahl flasks has been devised. It is provided with a handle so that the flasks can be taken from place to place in the laboratory as the operations require.

"This rack is made of wire and holds six Kjeldahl flasks of any of the three standard sizes. It costs three dollars." G. B. C.

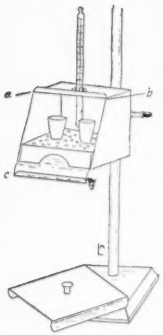
Protecting Combustion Tubes. G. L. VON PLANCK. *Chem.-Analyst*, **18,** 20 (Jan. 1, 1929).—To increase the life of silica combustion tubes by protecting them from spattering, a thin clay cover, molded in the shape of a split cylinder, has been devised. These covers are made from ordinary fire clay, molded in a mold made of plaster of Paris and with a short piece of oiled wooden dowel pin, dried in the air, and then ignited to about 1000°C. in an electric muffle. The clay is not vitrified at this temperature but the covers are hard enough to stand considerable handling and do not crack up when ignited.

Clay boats may also be made

with a simple plaster of Paris mold and wooden pattern. Not being vitrified, they do not crack from the heat, and last almost indefinitely.

A sketch of the boat with cover in place is shown herewith. M. W. G.

Drying Oven for Analytical Work and Preparations. F. HAHN. *Chem.-Ztg.*, **52,** 975 (Dec. 15, 1928).—Usually the hinges and bolt of a drying oven warp with the heat, the oven is shaken every time it is opened, often causing the crucibles to fall over or a part of the wall to fall off, thus contaminating the contents. The apparatus described here completely avoids this by doing away entirely with hinges. The door hangs on the edge *a-b* and lies on the oblique front of the furnace. To open it you simply lift it off and place it in the groove *c-d*. An iron rod fastened to the back of the furnace allows it to be fastened in any position or adjusted to any height suitable for the burner used. The thermometer is simply placed in an aluminum collar, a narrow hoop preventing its falling while it hangs quite freely in the sheath. If the collar is placed in the corner, large dishes as well as crucibles can be accommodated. The perforated tray fits very loosely and is easily removed. The whole oven, including thermometer sheath, being made of aluminum, is very easily kept clean. C. E. M.

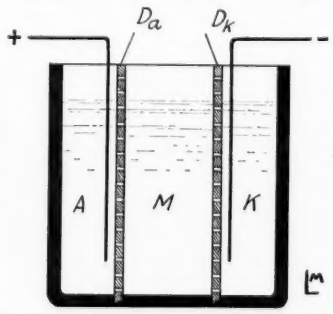


The Camerascope—Illustrating the Results of X-Ray Crystallography. *Laboratory*, **2,** 24–5 (1929).—The camerascope described is a folding stereoscope used for visualizing models of chemical compounds in three dimensions. Besides the camerascope, the outfit contains three illustrations of the x-ray spectrograph and 37 illustrations of the following crystal models:

1. Rocksalt
2. Fluorspar
3. Diamond (*a*)
4. Diamond (*b*)
5. Iron Pyrites
6. Iron Pyrites (*a*) (*b*)
7. Calcite
8. Spinel Structure
9. Rocksalt (*b*)
10. Calcite
11. Corundum
12. Graphite
13. Ice
14. Naphthalene
15. Diamond
16. Bismuth
17. Quartz
18. Quartz, Tridymite and Cristobalite
19. Quartz β
20. Quartz (axis)
21. Beryllium Acetate
22. Tartaric Acid
23. Racemic Acid
24. Cubic (Close)
25. Hexagonal (Close)
26. Tellurium
27. Fluorspar
28. Cesium
29. Zinc Blende
30. Wurtzite
31. Spinel
32. Iron Pyrites
33. Aragonite
34. Lithium Potassium Sulfate
35. Barytes
36. Chrysoberyl
37. Beryl

The complete outfit can be carried in the coat pocket and costs eighteen dollars. G. B. C.

Preparation of Pure Water. O. GERTH. *Chem.-Ztg.*, **53,** 52 (Jan. 16, 1929).—In this method pure salt-free water is prepared by electroösmosis, the process depending on the carrying of ions to their respective electrodes by a direct current. The system used is made up of three cells, as shown in the diagram, the middle compartment, *M*, containing the impure water, and the end compartments the electrodes. The latter are also kept full of water and are provided with overflow tubes. The cells are separated by porous diaphragms, chemically inert, which allow the passage of the ions to the electrodes where they give up their charge and combine with the water, the products of the electrolysis being carried off through the overflow tubes and not allowed to diffuse back into *M*.



A—Anode compartment with anode
M—Middle compartment
K—Cathode compartment with cathode
D_a and D_k—Diaphragms

For practical use, instead of only one of the above systems, several are used and in this way, three 250 liters of water an hour may be obtained, although the absolute

yield depends on the condition of the tap-water. This also determines the amount of current used; for water of medium purity, a yield of 100 liters of pure water requires 3–4 kw.-hours. If only partly salt-free water is desired, *e. g.*, water of 3–4° hardness for boiler feeds, by increasing the amount of water put through the operation, the yield may be increased 3-fold while the current is only 1–2 kw.-hours for 100 liters. This voluntary gradation in purity is one of the chief advantages of the method. If the water contains mainly carbonates, the cathode solution from which the carbonates have been precipitated by removal of carbonic acid may be withdrawn and allowed to settle; the clear supernatant liquid may then be used instead of tap-water and further purified.

If tap-water is used for flushing out the electrode compartment, dissociation products will be formed in *A* and *K* and ions will traverse *M*, using up current and slowing down the process. To avoid this, the anode solution is led from one anode compartment to the next, the cell thus being washed with water containing only anion products. The same is done with the cathode solution. Since the products of electrolysis accumulate, this over-flow stream is not allowed to proceed to the end of the apparatus but the last cell is washed out with previously purified water and back-diffusion is therefore somewhat decreased. This method of washing is very advantageous.

Everything is controlled automatically and no watching is necessary. The apparatus may therefore be allowed to run over night. C. E. M.

Marking Porcelain and Glassware. C. J. SCHOLLENBERGER. *Chem.-Analyst*, **18,** 17 (Jan. 1, 1929).—"By the use of a discarded piece of alundum ware, a good ground surface is easily made on glass or porcelain, the edge of the alundum crucible is wetted and rubbed with short firm strokes at the place desired for a few seconds. Surfaces so ground take pencil more readily than the usual sandblasted label, and the mark is more readily erased with a pencil eraser when desired. Even porcelain crucibles marked thus may be ignited and the mark survive several ignitions, but for this purpose ink is better; the iron in the ink will make the characters permanent after ignition. Ground surfaces produced in this manner have not been found to increase liability to breakage on heating.

"Porcelain and silica ware may also be marked with platinum, when properly done producing very neat and legible characters. About a decigram of scrap platinum may be dissolved in aqua regia in a small porcelain crucible and the solution evaporated nearly to dryness. About one ml. lavendar oil is added and the mixture stirred until permanently mixed. The ware is slightly warmed and this mixture applied with a rubber stamp or thinly painted on with a fine brush, sharpened match, or something of the kind. The ware is gently heated to burn off the oil and finally strongly ignited to fuse the metal into the surface producing a distinct black mark. If applied too thickly the characters may be blurred, or may be a metallic mirror less distinct than the black deposit. If the mixture becomes gummy after long keeping, it may be thinned with a little more of the oil." M. W. G.

Marking Ink for Chemical Porcelain. N. W. MATTHEWS. *Chem.-Analyst*, **18,** 22 (Jan. 1, 1929).—"Take 18.8 grams cobalt oxide, black commercial, and 1.2 grams bismuth subnitrate. Grind these together thoroughly with 15 cc. turpentine and 15 drops Dresden thick oil.

"Mark the porcelain with a pen, heat slowly to evaporate the liquids, and then ignite strongly. The porcelain apparatus is then ready for use." M. W. G.

The Marking of Glassware by Lead Etching. J. W. ROBBINS. *Chem.-Analyst*, **18,** 18 (Jan. 1, 1929).—1. Take a quantity of lead oxide and place in a dish and warm slightly over a flame to remove traces of moisture. Break up all lumps to a fine powder. Either litharge or red lead give satisfactory results.

2. The glass to be etched must be free of finger prints, moisture, and grease.

3. An ordinary rubber stamp having the desired lettering and an ordinary stamp pad are used. Stamp the wording on the part to be etched, shake a small quantity of litharge over the wording, and brush off the excess lead with a camel's hair brush. The ink acts only as a binder for the oxide.

4. Run through the flame until the oxide has a glossy appearance. In some cases wording may become black due to the formation of a higher oxide of lead by the use of the oxidizing part of the flame. This higher oxide may be removed by holding in the extreme upper part of the flame, and burning the oxide off, leaving a clear etching.

5. Care must be taken that too hot a flame is not used as this has a tendency to spread the lead. M. W. G.

The Numbering and Lettering of Apparatus. G. G. GIFFORD. *Chem.-Analyst*, **18,**

16 (Jan. 1, 1929).—"Number and letter your apparatus, flasks, test tubes, beakers, etc., which are used daily in making routine analyses, with a good grade of auto enamel of any desired color. Place the number or letter on the etched circle either with a marking brush or toothpick. When desired to move number or letter scrape off with knife blade or edge of tool and rub stain off with carbon tetrachloride or some other efficient solvent."

This method is much more satisfactory and economical than the usual marking pencils. M. W. G.

Waterproof Varnish for Paper Labels on Reagent Bottles. C. J. SCHOLLENBERGER. *Chem.-Analyst*, **18**, 17 (Jan. 1, 1929).—"An excellent varnish for this purpose may be made by dissolving transparent celluloid in acetone, making the solution to about the consistency of heavy sirup. It is to be painted on with a brush and dries very quickly, giving labels an attractive glazed appearance without greasiness or loss of transparency and thoroughly waterproofing them. It may also be used as paste for attaching labels, and as cement for repairing all articles made from celluloid.

"Old photographic film from which the emulsion has been removed by soaking in warm caustic solution and thorough washing in water is a good form of celluloid for the purpose." M. W. G.

Prolonging the Life of Rubber Stoppers. C. J. SCHOLLENBERGER. *Chem.-Analyst*, **18**, 20–1 (Jan. 1, 1929).—"The rubber stoppers used in distilling flasks (*e. g.*, for nitrogen by the Kjeldahl method, etc.) must generally be replaced long before worn out, because the rubber has shrunk to such an extent that a tight fit in the neck of the distilling flask is no longer possible. This is caused by the tendency of the heated rubber to maintain its shape on cooling, and as hot rubber contracts considerably on cooling, the rubber stopper is soon too small to fit. By disconnecting the stoppers while still hot, rather than letting them cool slowly in the necks of the flasks, they have a better chance to resume their proper shape, and their useful life will be considerably prolonged. When finally shrunk so that they are no longer safe to use, they need not be replaced by new ones. Remove the shrunken stopper and insert in the perforation a piece of rubber tubing a little longer than the depth of the stopper, and of suitable diameter to go in with some difficulty. Wet the inside of the tubing and force the glass tube of the stillhead into place. The extra diameter thus given the stopper will make it fit the flask as well as a new one. The operation may be repeated when necessary, putting the new piece of tubing inside the old. Thin-walled, smooth, white machine-made tubing has been found best for the purpose. A similar result may be secured by applying the thin "band tubing" sold for use with Gooch crucibles to the outside of the stopper; this is more easily done but the repair is less permanent.

"When many flasks are used with a battery of stills, it is advantageous to calibrate the necks of the flasks and number the latter so that only those of practically the same neck diameter will be used with a particular stopper. When the stoppers become too small, the flasks may be renumbered so that those of the next smaller neck diameter will be used with each stopper and only the smallest of these will have to be changed at that time." M. W. G.

A Quick Method for Making Starch Solution. J. C. BAILAR. *Chem.-Analyst*, **18**, 14 (Jan. 1, 1929).—"Puffed rice is practically pure starch in which most of the starch grains have been ruptured and is therefore an ideal substance for making a starch solution. The procedure is as follows:

"Into 100 cc. of boiling water drop about 20 granules of puffed rice. Allow to boil until all the granules disintegrate. This should require less than a minute. Remove from the heat and allow to settle, when it is ready for use. The undissolved parts settle quickly and the supernatant liquid is poured off. If the solution is not the right strength the amount of rice can be varied to suit the operator." M. W. G.

A Quick and Efficient Method for Filtering Agar. *Laboratory*, **2**, 23 (1929).—"The agar shreds are put into a liter of water. This is allowed to stand for several hours. The amount of dirty water removed is replaced by clean water. Then add peptone, salt, and extract and place in a flowing steam (Arnold) sterilizer.

"While the agar is melting make a filter of a layer of absorbent cotton between two pieces of double cheese cloth. This pad is put into a large Buchner funnel (200 mm.) and placed in the Arnold sterilizer for ten minutes. After removing the agar from the steamer, filter through the hot funnel. This is a very quick method whereby it is possible to filter ten to fifteen liters of agar at one time.

"It is not necessary to use egg albumin in the agar as it adds no value to the media, and it clogs the filter." G. B. C.

How to Relacquer Scientific Instruments. *Laboratory*, **2**, 27 (1929).—"Dissolve

15 grams of shellac in 120 cc. of pure grain alcohol. Stopper and allow to stand about three days and then filter.

"The lacquer for nickel, aluminum, and other white metals should be made with white shellac. The lacquer for brass should be made with orange shellac.

"In using apply a thin coat of lacquer with a camel hair brush. Care must be taken to lacquer only those parts once lacquered by the manufacturer.

"Lacquer flows more evenly and smoothly if the metal is warmed before applying the lacquer. A better job can be made if the old lacquer is first removed from the entire piece. Alcohol is the best solvent for removing shellac lacquer and amyl acetate for cellulose lacquer." G. B. C.

Ink Erasing Fluid. N. W. MATTHEWS. *Chem.-Analyst*, **18,** 22 (Jan. 1, 1929).—"An alkali hypochlorite, first applied to the ink to be removed, followed by an application of dilute acid, will remove ink from paper." M. W. G.

Ink Stains. N. W. MATTHEWS. *Chem.-Analyst*, **18,** 22 (Jan. 1, 1929).—"To remove red ink stains, cover the spot with strong $KMnO_4$ solution for five minutes. Then place the material in an oxalic acid solution so that the $KMnO_4$ spot disappears. A rather strong solution of $NaHCO_3$ may be used to neutralize the oxalic acid. Wash the material thoroughly with water. Repeat if the stain is not completely removed. Black stains may be removed in a similar manner. Always wash well with fresh water after using these solutions.

"This method has worked exceedingly well on several occasions. Several very large black ink spots were once completely removed from a woman's white satin skirt. The skirt, after being pressed, showed not the slightest trace of either the ink or of the chemicals used for its removal." M. W. G.

A Cement. N. W. MATTHEWS. *Chem.-Analyst*, **18,** 22 (Jan. 1, 1929).—"When a cement for porcelain, metals, or stoneware is desired, casein mixed with sodium silicate and lime makes an efficient mixture. To make this, dried casein is soaked in an equal weight of water for two hours. The casein swells, but does not dissolve. At the end of that time the sodium silicate and lime are stirred in and the cement is ready for use. M. W. G.

A Color Reagent for Metallic Salts. N. W. MATTHEWS. *Chem.-Analyst*, **18,** 22 (Jan. 1, 1929).—"A solution of NH_4SCSNH_2, prepared by adding 3 or 4 volumes of concentrated NH_4OH to CS_2, warming slightly and decanting from the unchanged CS_2, gives color reactions with the salts of a number of metals, of which the following are the most characteristic:

"Cu, brown precipitate and violet solution; Pb, red precipitate and yellow mother liquid; Bi, orange yellow precipitate; Ni, carmine red precipitate, red solution." M. W. G.

Estimation of Mixtures of Methyl and Ethyl Alcohols. S. KETTLE. *Chem.-Analyst*, **18,** 7 (Mch. 1, 1929).—"The mixed alcohols are oxidized with a mixture of sulfuric acid and potassium bichromate. The C_2H_5OH is converted into CH_3COOH, and the CH_3OH into CO_2 and H_2O. The products of the reaction are passed into a large excess of ammoniacal barium chloride solution, as in a CO_2 estimation. The CO_2 forms $BaCO_3$, which is precipitated, and the CH_3COOH gives CH_3COONH_4, which is soluble. The $BaCO_3$ is filtered off, decomposed with *N* HCl and the excess titrated back. From the amount of $BaCO_3$ may be calculated the content of CH_3OH. Factor is 0.1625." M. W. G.

The Educational Museum of the Cleveland Public Schools. W. M. GREGORY. *Educ. Screen*, **8,** 39–40 (Feb., 1929).—A distinction is made in materials to be used in the classrooms over against those for general entertainment in the auditorium. Care is taken to not get fragile, bulky, or dangerous materials. The material is organized into units which may consist of twenty-five or fewer lantern slides or mounted pictures. Exhibits whether bottled or mounted are provided with box containers which may be used readily in making shipments.

Methods of administration and distribution of this material to schools and classrooms is described. The relation of such material to the course of study both in its construction and its use is discussed. B. C. H.

KEEPING UP WITH CHEMISTRY

Storage Batteries, Their Care and Use. J. B. LUCAS. *Bull., Eng. Ext. Div., Va. Polytechnic Inst.*, No. **15** (Apr., 1928).—This article is clearly written and is comprehensive. Copies may be obtained on request. M. W. G.

Petroleum as a Source of Synthetic Material. ANON. *Chem. Age*, **20,** 118–9 (Feb. 9, 1929).—Review of a paper presented by Dr. Dunstan before the London

section of the Society of Chemical Industry. The oil interests in America have subscribed 500,000 dollars, in the past few years, for fundamental research in petroleum. The different lines followed by this research are enumerated. "All this fundamental research must ultimately give us a new chemistry based on the paraffins, just as today we have a chemistry based on the aromatic hydrocarbons." E. R. W.

The Story of Carbonated Beverages. L. B. STORMS. *Pract. Home Ec.*, **7,** 40 (Feb., 1929).—Carbonated beverages, while primarily beverages, are also properly classified as foods. They contain pure water, sugar, fruit acids, fruit flavors, synthetic flavors, and carbon dioxide. They aid in drinking the necessary amount of water.

The average sugar content is 11.19%, meaning the average 6 fl. oz. bottle has approximately 76 calories. Acids used are citric, tartaric, lactic, acetic, and phosphoric. The fruit acids are partly responsible for the decided appetizing effect of the beverages.

Nutrition experiments with albino rats show better growth and reproduction when carbonated beverages are added to the basal diet.

The majority are colored with caramel or caramel with other coloring.

The carbon dioxide present has a destructive effect on various micro-organisms. It also promotes flow of saliva, tends to allay nausea and gastric irritability, aids digestion, aids in rendering body fluids alkaline, promotes diuresis, and imparts a sense of well-being. It is a powerful respiratory stimulant.

As very pure water must be used in their preparation they furnish a very much better and safer drink than water which is usually available. J. W. H.

Adsorptive Stratification in Gels. S. C. BRADFORD. *Chem. & Ind.*, **48,** 78–81 (Jan. 25, 1929).—This paper is a reply to a recent paper by E. S. Hedges. The author maintains that, ". . . up to the present, no serious objection to the adsorption theory (of Liesegang's rings) has been made, and study of my papers will show that the adsorption theory is capable of explaining qualitatively all the known facts connected with the occurrence of banded precipitates." E. R. W.

Surface Energy in Chemical Engineering. ANON. *Chem. Age*, **20,** 146–7 (Feb. 16, 1929).—A detailed review of a paper presented by Professor W. E. Gibbs. Among the topics discussed and related to chemical engineering are the following: inter-molecular forces, surface tension, adsorption, flotation, emulsification, de-emulsification, lubrication, and contact-catalysis. E. R. W.

Low-Temperature Carbonization and Coal Liquefaction. ANON. *Chem. Age*, **20,** 120–1 (Feb. 9, 1929).—A review of Dr. Landers third Cantor lecture. Deals with low-temperature carbonization in Great Britain, hydrogenation of coal, and the products formed by hydrogenation. E. R. W.

Basic Industrial Minerals: Bauxite. G. M. DYSON. *Chem. Age*, **20,** 150–1 (Feb. 16, 1929).—Bauxite, the red "clay" of Les Baux, has been known to scientists for a little over 100 years. The deposits of bauxite in different parts of the world are mentioned briefly, while the composition, purification, and applications of this ore are discussed in more detail. E. R. W.

Lamp Black. F. GROVE-PALMER. *Chem. & Ind.*, **48,** 60–1 (Jan. 18, 1929).—The industrial methods of preparation and the uses of lamp black are discussed. It is used extensively in the following industries; electrical, paper, rubber, artificial leather and other coverings, ink and paint. E. R. W.

Glass and Enamel. *Silicate P's & Q's*, **9** (Mch., 1929).—The article deals largely with enamels, their uses and the manufacture of enamelware.

The enameling of metallic surfaces requires care and skill. Some of the factors that must be considered are: period of heating, thickness of coating, choice and proportioning of the ingredients of the enamel, the melting point of the silicate mixtures, coefficient of expansion and contraction of enamel and substance to be enameled, cost of materials, luster of finished product, resistance toward acid solutions. Silicate enamels satisfy the factors mentioned. E. L. M.

The Stainless Steels and Irons and a Steel Which Is Stainless though Not a "Stainless Steel." L. W. SPRING. *Chem. Bull.*, **16,** 81 (Mch., 1929).—The story is told of the first cutlery which was manufactured of previously known "stainless steel."

The "stainless steels" contain 12 to 18% chromium and 0.3 to 0.5% carbon. In order to be corrosion-resistant they must be hardened and polished. They are fairly resistant to fire and flame. If the carbon content is less than 0.1%, "stainless irons" result (alloys containing more than 0.1% carbon are called steels, those containing less than 0.1% carbon are called irons). Nickel added to stainless alloys aids their resistance to oxidation and corrosion but makes machining and forging more difficult.

"Nitralloy" is a newcomer. It is made from steels containing 1 to 2% aluminum

and either $\frac{1}{2}$ to 1% molybdenum or 1% chromium, by subjecting them to a temperature of 900° to 1000°F. and passing anhydrous NH_3 over them. The aluminum nitride formed seemed to be responsible for the very hard surface layer, which is very resistant to wear, is rust-proof and stainless. "Nitralloy" is easily worked and does not require tempering after removal from nitriding process. E. L. M.

Pennsylvania Slate Quarries Adopt New Mechanical Aids. R. G. SKERRETT. *Comp. Air Mag.*, **34,** 2687–94 (Mch., 1929).—A well-illustrated descriptive article giving the story of these quarries. E. R. W.

HISTORICAL AND BIOGRAPHICAL

In Quest of the Original Reflux. D. B. KEYES. *Sci. Mo.*, **28,** 274–8 (Mch., 1929).—K. gives a brief description of the essential features of the modern fractionating column and shows how the design of distillation apparatus of the 16th and 17th centuries applies the same underlying principles. The basic features are a heating coil at the bottom of the column, the entrance of the feed in the form of a vapor or liquid at the side of the column and a reflux condenser to return part of the condensed vapors to the top of the column. Several drawings of the early types of distillation apparatus illustrating these principles are given. G. W. S.

Was Biblical Ophir in the Kongo? O. LETCHER. *Comp. Air Mag.*, **34,** 2707–11 (Mch., 1929).—An interesting article telling of ancient gold workings in the Kongo. E. R. W.

EDUCATIONAL MEASUREMENTS AND DATA

The Objective Determination of Pupil Achievement. M. S. ALLEN. *California Quart. Sec. Educ.*, **4,** 147–9 (Jan., 1929).—The author reports a non-mathematical plan to assist in the immediate detection of those pupils who are working below their normal capacity. An I. Q. achievement graph is used, the intelligence quotients of the class being arranged horizontally in descending order. Both achievement scores and I. Q.'s are expressed in terms of medians and plotted against each other. For example if a pupil's achievement score is 60 and the median score of the group is 50, the median achievement score is 60 divided by 50 or 1.2. A glance at the chart shows those who are not working up to capacity, so remedial measures can immediately be taken. In the example a pupil is said to be working below capacity if his median I. Q. quotient is above 1.2. C. M. P.

Standardized Tests for Students of Education. M. D. ENGELHART. *Educ. Admin. & Superv.*, **15,** 93–101 (Feb., 1929).—The tests in use are described and discussed. Other work which is being done in this field is presented. Bibliography is included. In the opinion of the writer two tests are outstanding because of construction and standardization; "Aptitude Tests for Elementary Teachers, Set 1" and the "Stanford Educational Aptitudes Test." Criticisms of the tests are made and suggestions given for improving the tests in use and constructing new ones. S. R. P.

Helping Your Students. What Will Their College Cost? BUREAU OF EDUCATION. *Ohio Teacher*, **59,** 251–3 (Feb., 1929).—A table compiled by the *Bureau of Education* giving the tuition and fees and board and room expenses for 96 state colleges and universities.

Excluding clothing, amusements, and travel the average minimum expense for nine months in residence at a state college is $464.00. Board and room is the largest item.

For state residents, tuition and fees in the publicly controlled colleges average $78.00. In non-sectarian privately controlled colleges, $255.00 (in 114 accredited institutions) and $163.00 (in 28 non-accredited colleges). For institutions under church control the tuition average is $167 for accredited and $128 for non-accredited institutions. S. R. P.

The Development of Quantitative Units for High-School Physics. COMMITTEE REPORT. *N. Central Assoc. Quart.*, **3,** 589–614 (Mch., 1929).—The committee prepared five teaching units, constituting a portion of a year's course in high-school physics. These units were given experimental try-outs and used for instruction in ten classes in four schools, taught by five teachers. The titles of the five units were: (1) What are hydrometers, for what are they used, and how do they illustrate an essential phase of science? (2) What are machines and of what value are they? (3) Principles of liquid and gas pressure and their applications in water and gas supply systems. (4) Applications of the principles of fluid pressure in water and air craft. (5) Heating, ventilating, and humidifying systems. Ultimate aims for each unit are stated. Knowledge elements designed to accomplish these aims were next listed, followed by the technics

for their accomplishment. Appreciations were next listed and finally habits and skills. The four immediate aims were stated in terms of pupil activities. Preliminary and final tests were prepared for each unit. The report includes complete data for each unit. Seniors did better than juniors, and pupils who had had general science did better than those who had not had general science. C. M. P.

THE METHODS AND PHILOSOPHY OF EDUCATION

The Philosophy of American Education. W. H. KILPATRICK. *Teachers J. & Abstr.*, **3**, 540 (Nov., 1928).—Abstract of article from *Teachers College Record*, October, 1928.

Statement of the philosophy of American education to a group of German educators in terms of the "how" or method and the "what" or curriculum in light of the history of the rise of such philosophy.

As to "how," it is purposeful, self-imposed activity on the part of the learner and as to "what," it is a succession of experiences, a life process. S. R. P.

The State University: Its Relation to Public Education. L. D. COFFMAN. *High-Sch. J.* (Chapel Hill, N. C.), **12**, 21–33 (Jan., 1929).—Public schools and state universities were founded upon the assumption that society's welfare is best promoted by providing as nearly free and equal educational opportunities as possible. The author discusses the many criticisms which have been made of the entire educational system, and especially institutions of higher learning. He discusses such questions as the purposes and functions of colleges in a democracy, costs of public education, limiting number of students admitted to college, raising admission requirements, greater elimination of students in college, increasing fees and tuition, and purposes of public and private institutions of higher learning. C. M. P.

The Crucial Problem of the Next Decade. W. C. BAGLEY. *J. Nat. Educ. Assoc.*, **18**, 107–8 (Apr., 1929).—Public education is between two fires. On one side, it is tempted by the soft sentimentalism of the extreme freedom theory: on the other side, it is assailed by the hard materialism which stigmatizes the budgets for public education as "sanctified squander." Public education will solve these problems by hard thinking and heroic action and reach the plane of a virile, practical, and dynamic idealism. For a motto Dr. Bagley suggests "Through Discipline to Freedom." A. E. C.

Education: What Program? What Price? F. D. BOYNTON. *J. Nat. Educ. Assoc.*, **18**, 69–72 (Mch., 1929).—Mr. Boynton discusses how the responsibilities of the home have shifted to the school since 1775. He contrasts the American and European schools and the results of their educational methods. He points out the present industrial and economic changes which are creating a greater amount of leisure for all and what part education should play in the spending of this leisure time. He explains why the cost of maintaining the public school will be and should be a steadily mounting sum. A. E. C.

Hoover's Faith in Education. W. HARD. *California Quart. Sec. Educ.*, **4**, 101–7 (Jan., 1929).—This article is a reprint of an interview with Herbert Hoover previously reported by William Hard in *Good Housekeeping*, April, 1928. Mr. Hoover believes that equal opportunity develops a variety of talents. Leadership comes automatically if people are given an equal chance. Mass education lessens snobbery. Education should be such as not to make us ashamed to work and look down upon manual labor as somewhat degrading. The elective system in college is very valuable, and, differing with the opinions of some, Mr. Hoover believes that colleges do not produce uniformity. This lack of uniformity is very desirable and tends to keep college graduates out of the ruts and makes them less narrow-minded than European college graduates. Our advanced industrial position can be attributed to leadership developed through mass education. Education of girls is of equal importance to that of boys in the opinion of Mr. Hoover. Universal education should be of the type that is inspirational as well as instructional. Efficiency is not the final goal to strive for. "The glory of America is identical chances and differentiated results. The business of getting educated is our biggest and only indispensable business. Our school business is the business—fundamentally—that has made us what we are." C. M. P.

Informationalism versus Institutionalism in Education. G. FRANK. *N. Central Assoc. Quart.*, **3**, 310–23 (Dec., 1928).—In the opinion of the author less progress has been made in promoting a liberal education than any other phase of the American educational system. Schools of law, medicine, engineering, commerce, agriculture, and the like are becoming better and better instruments for giving effective training in subject matter and technic of the professions and trades. President Frank says that a liberal education "means primarily the ability to think clearly, creatively, and

objectively outside of one's speciality as well as inside one's speciality." Futile attempts to accomplish this end have been made, first through the classics, later by means of the natural sciences, and lastly by means of orientation and summary courses. American education during the past fifty years has had two main developments: first, intensive specialization in the presentation of subject matter, and second, extensive freedom in the selection of studies under the elective system. These two developments have led to suicidal specialization by some students and to suicidal smattering by others. Notebooks, examinations, and the credit system come near to making liberal education impossible in a modern college. The University of Wisconsin is carrying out an experiment in which an attempt is being made to break through the bonds of institutionalism. C. M. P.

"DeBunking" the Master's Degree. C. S. SLICHTER. *N. Central Assoc. Quart.*, **3,** 463–7 (Mch., 1929).—The college and university catalogs of fifty years ago contained a statement which read, "The degree of Master of Arts will be conferred on Bachelors of three years' standing who have sustained a good character and furnish proof of having pursued professional or other advanced studies. Applications should in all cases be made before commencement, accompanied by a fee of five dollars." The real requirements were the lapse of time and the payment of five dollars. Then in the "gay nineties" a revolution in higher degrees occurred and a year of resident study and a thesis were required. Schools and colleges began to offer financial rewards to holders of Master's degrees. Correspondence courses, extension work, and summer schools resulted from the demand of candidates to short-circuit the route to the degree. Most colleges now have dual standards that meet requirements for the master's degree—one for those in residence during the academic year and another for those attending summer schools. Some institutions are now granting master's degrees after the completion of 24 weeks' work and do not require a thesis. The author believes that the possession of a Master's degree should have some significance, that a full year's work should be required, and that work done by correspondence or *in absentia* should not be credited. C. M. P.

Protect the Ph.D. E. C. HIGBIE. *Educ. Admin. & Superv.*, **14,** 555–8 (Nov., 1928).—We should have a new degree for those who wish to teach in the teacher training institutions, reserving the Ph.D. for those interested in research. For the present this degree should be somewhere between the Master's and the Doctor's, but ultimately made equivalent. It should demand abilities making for the master teacher, not those necessary primarily for research. S. R. P.

Secondary Education in 1928. J. T. GILES. *J. Nat. Educ. Assoc.*, **18,** 91 (Mch., 1929).—Secondary school enrolment is tending upward. The consciousness of the need for a common basic theory of American education has grown perceptibly. The reorganization of high-school curriculum is still a large problem. Reform in technic of teaching is under way. There is still a great need for supervision of instruction, because of new methods. Extra-curriculum activities have increased rapidly. Pupil-guidance is an increasing function of administration and the high-school principal is becoming more conscious of his growing problems. A. E. C.

Trends of Secondary Education as Shown by Reports of Some Major Committees. E. H. SANGUINET. *Educ. Admin. & Superv.*, **14,** 559–73 (Nov., 1928).—A summary of the content and influence of "The Committee of Ten," "The Committee of Fifteen on Elementary Education," "The Committee on College Entrance Requirements," "The Commission of Twenty-One," "The Committee on Six-Year Courses," "The Committee on Economy of Time," and "The Commission on Reorganization of Secondary Education."

Bibliography included. S. R. P.

What Modifications in the Technic of Instruction Should Be Made for Superior Children? E. H. SANGUINET. *Educ. Admin. & Superv.*, **15,** 58–66 (Jan., 1929).—A summary of the literature and a series of recommendations for dealing with the education of the precocious child.

The writer indicates that the fact of so many bright children leaving the schools shows a need for proper handling of this type of student. S. R. P.

Diagnosis as a Basis for the Direction of Study. M. N. WOODRING AND C. W. FLEMMING. *Teachers J. & Abstr.*, **3,** 538 (Nov., 1928).—Abstract of article in *Teachers College Record*, October, 1928.

The fifth in a series on the direction of study.

It is important to recognize the difficulties in the learning process as revealed through careful observation of study habits. A detailed outline for diagnostic procedure is presented. Some of the items in this outline considered as contributing to

poor study results are: (1) mental ability, (2) ability in reading, (3) scores in other objective tests, (4) school marks, (5) health, and (6) home conditions.

Any one of these may become of serious consequence. S. R. P.

The Intermediate Assignment. C. C. WATERHOUSE. *High-Sch. Teacher*, **5**, 72–3 (Feb., 1929).—Varying abilities and capacities of students in physics lead to the development of a system of lesson assignment to meet these varying needs.

The semester's work is split up into units which are called projects. Each unit has a time limit. The assignment for each in the form of reading, experiments, problems, and exercises, etc., are assembled upon a card or sheet and is issued to the student as mastery of the preceding unit is shown.

A sample of a project sheet is exhibited and the full list of the year's units is also given. Morrison's plan of subject-matter mastery is followed in the teaching procedure. B. C. H.

The Scarsdale Plan. R. UNDERHILL. *J. Nat. Educ. Assoc.*, **18**, 77–8 (Mch., 1929).—A brief outline of the Scarsdale plan for elementary and secondary grades. A. E. C.

Educational Trends in Post-War Europe. B. ENSOR. *Prog. Educ.*, **6**, 45–53 (Jan., Feb., Mch., 1929).—Progressive education in Europe has made great strides during the last ten years. Educational leaders are attempting to break through the barriers of conservatism and tradition, and establish schools more in keeping with modern needs and the findings of psychology. Activity schools are being established everywhere and the Dalton plan and its modifications have made a great impression in England where there is an increased tendency to overestimate materials. In Germany school journeys are an important element in the curriculum. France has probably made fewer changes than any other country. Progress in England has been evolutionary rather than revolutionary. Little has been accomplished in intelligence testing and in any basic reforming of the curriculum. Revision of the curriculum is necessary before much more progress is possible. C. M. P.

Some Reasons for the Superior Quality of Scholarship in European Schools. S. P. CABOT. *Prog. Educ.*, **5**, 359–65 (Oct., Nov., Dec., 1928).—It is generally conceded that graduates of the French, German, and English secondary schools are far in advance of American high-school graduates as intellectual equipment goes. Reasons for this superiority are: (1) highly selective basis (intellectually and financially) of those permitted to enter secondary schools, (2) continuous and definite course of study leading up to clearly defined cultural goals—real mastery of the subjects studied gained by comprehensive and intensive effort, (3) high academic and intellectual qualifications of the teachers. Secondary schools in Europe aim to develop leaders from the intellectual élite—not to raise the educational level of the masses. C. M. P.

Education in Italy. H. J. FELLS. *Educ. Outlook*, **80**, 387 (Dec., 1928).—Some of the outward manifestations of the Fascist regime in its control of education. Private schools are placed on the same level as the public schools. The present system takes on a scientific rather than practical aspect. Elementary and secondary schools are briefly described. While the end is set teachers are left free as to method. There is a great interest in adult education. It is held that there is still greater need for direct relation of education to life.

There is a short description of the schools of Italy before the Fascist educational reforms of 1923. S. R. P.

Utopia College: A Prospectus. A. HIBBARD. *Outlook*, **151**, 9 (Feb. 27, 1929).—The author's ideas of the aims, structure, and operation of the ideal college. G. H. W.

THE PHILOSOPHY OF SCIENCE

The Chemist and His Message. W. HUBBALL. *Chem. & Ind.*, **47**, 1110–3 (Oct. 26, 1928).—A discussion of scientific, particularly chemical, literature, with the purpose of explaining and perhaps excusing its usual lack of literary merit. The technologist is, "....the only man in the world who has something to say and the only man who does not know how to say it." Perhaps he is, in the words of H. G. Wells—"writing for the sake of the matter and not for the sake of the writing." However good this excuse may be, the need for more careful training of scientists in literature and in the art of writing is pointed out. A discussion of the paper by several scientists is given. E. R. W.

The New Vision of Science. P. W. BRIDGEMAN. *Harper's*, **158**, 443 (Mch., 1929).—The influence of science colors the entire mental outlook of modern civilized man on the world about him. The conviction that the world is understandable is the most important gift of science to civilization. As a corollary man feels he is in

a congenial universe. This is a result of the discoveries of Newton, but the recent scientific discoveries have in store an even greater revolution in our entire outlook. Former conclusions were based on the narrowness of our horizons and if we sufficiently extend our range we shall find nature is intrinsically in its elements neither understandable nor subject to law. The newer experimental facts which will cause this change are in the range of the quantum phenomena. Many illustrations are given to show what the ultimate effect will be. J. W. H.

The Pioneering Professor. M. PUPIN. *Scribner's*, **85**, 123–6 (Feb., 1929).—Professor Pupin in this short article on "The Pioneering Professor," points out that most of the fundamental scientific discoveries that have been developed by the industries came from the investigations of the university professor. The university research laboratory is one of the invisible services of science rendered by the university professor. The scientific idealism of this laboratory has penetrated and enthused the great industrial laboratories so that both are motivated by an unselfish search of the eternal truth. The mental attitude of both is open-minded and unprejudiced in the interpretation of the language of nature. "The method of inquiry is observation, experiment, and calculation. This is the philosophy of great pioneers in science whose achievements conferred innumerable blessings upon humanity. One of the greatest of these blessings is the growing public belief that this philosophy of scientific idealism is the safest guide in all human activities." F. B. D.

Freedom of Teaching Science. EDITORIAL. *Bull. Am. Assoc. Univ. Profs.*, **15**, 96–7 (Feb., 1929).—Reports the committee action as adopted at the recent New York meeting. A committee from the Association of University Professors is to coöperate with a similar committee from the American Association for the Advancement of Science in preparing a pamphlet upon the freedom of teaching in science. This pamphlet is to be for general distribution.

The recent Arkansas legislation, which initiated the above action is said, by the committee, "not to greatly interfere with the teacher's instruction concerning evolution." The particular ban is on teaching "that mankind ascended or descended from a lower order of animals." Animals may be taught as ascended or descended from other animals so the essential element in the principle of evolution may be still a part of the courses in biology. B. C. H.

THE TEACHING PROFESSION

How Teaching Can Be Improved. F. D. BOYNTON. *J. Nat. Educ. Assoc.*, **18**, 72 (Mch., 1929).—1. By a thorough and comprehensive knowledge of the subject matter taught kept down to date. 2. By professional training, a thorough and comprehensive study of how to put the thing over. 3. By supervised instruction. 4. By an agreement of full and associate professors that each will teach one or more divisions or sections of freshmen. A. E. C.

Teachers Talk Too Much. W. A. MILLER. *J. Nat. Educ. Assoc.*, **18**, 74 (Mch., 1929).—The word "educate" means to lead forth and not to pour in. Learning is doing and it is the children who are supposed to be doing the learning. Therefore, it would be advisable for the average teacher to reduce the amount of time he spends talking to his class by half. A. E. C.

Research in Science Teaching. S. R. POWERS. *Teachers J. & Abstr.*, **4**, 105–6 (Feb., 1929).—Summary from *Teachers College Record*, January, 1929.

The objectives of science teaching involving practical or applied and cultural or liberalizing values must first be obtained. Then the most efficient learning methods for the attainment of these objectives determined. Finally, research is needed to discover how teachers may most effectively be placed in possession of these objectives and the knowledge of the best methods for their attainment. S. R. P.

The Training of Teachers. C. C. LITTLE. *N. Central Assoc. Quart.*, **3**, 324–32 (Dec., 1928).—The three major fields of activity in which the training of teachers manifests itself are: first, in the knowledge of subject matter; second, in the methods of instruction; and third, in the knowledge of the nature of the pupil. "We all know that subject matter has been done up by administrative officers and by teachers themselves in packages of all sorts and sizes, and some in their original and native acidity. These have been fed to students at times when they were prepared for it, and at times when they were not. It has been rammed down their throats and it has been dragged before them like a string before a kitten in the hope they will jump at it. It is *not* our duty merely to polish off what is given us, merely to assert and rearrange subject matter and devise new methods. It *is* our duty to study *why* we are doing certain

things and whether the results we are attempting to attain are being realized, and whether, if so, they are permanent or temporary." Too little attention has been paid to studies involving the analysis of the nature of the child and, relatively, on overemphasis on subject matter and methods. There needs to be a close partnership between education and youth, and between religion and education and youth, if we are to go ahead. C. M. P.

The Relation of the Training to the Selection and Placement of Teachers. E. W. ANDERSON. *Ohio Teacher*, **59**, 207, 208, 224 (Jan., 1929).—A discussion of the present and desired future relation between supply and demand in particularly the Ohio Schools.

At present there is but a distant relation between subjects taught and the training of the teacher, English majors being the worst offenders. The situation with inexperienced beginning teachers is especially bad.

Teachers should be trained for a variety of subjects, including the non-academic such as physical training, home economics, etc. Too few institutions train their graduates for the teaching of general science, problems of democracy, commercial arithmetic and geography, occupations, and physiology. Perhaps too much attention is given to education courses at a time when the student does not understand problems of teaching. Wider practice teaching is desirable. Perhaps improvements can come through a standardized grouping of certain courses in the training school. S. R. P.

Training and Experience of Teachers in the Junior Colleges of California. E. H. MORTENS. *California Quart. Sec. Educ.*, **4**, 51–8 (Oct., 1928).—Approximately 7 per cent of the teachers in the junior colleges of California hold at least the Doctor's degree, 46 per cent the Master's degree, and 90 per cent the Bachelor's degree, and 10 per cent no degree. The latter are usually teachers of such subjects as art, music, shop, physical education, and the like. Institutions from which degrees were obtained are widely scattered throughout the United States, and a few foreign countries are represented. The median number of years of experience is 10 years ranging from 2 to 4 years. Approximately 34 per cent have had previous experience in teaching, 54 per cent having had experience outside of California. C. M. P.

A Study of the Relation between Teaching Efficiency and the Amount of College Credit Earned While in Service. H. M. BARTHELMESS AND P. A. BOYER. *Educ. Admin. & Superv.*, **14**, 521–35 (Nov., 1928).—A study made by the Division of Educational Research covering 5002 elementary and 1220 junior high-school teachers.

Diagrams, graphs, tables, and statistical data are included.

Conclusions: Neither elementary nor junior high-school teachers take a great amount of work while in service; there is a low positive correlation between experience and credits; a low positive correlation between experience and efficiency which is greater in the early years of teaching; amount of college work pursued in service is positively correlated with efficiency; but the relation is low. S. R. P.

Participation in Testing Programs by the Classroom Teacher. I. U. MADSEN. *Educ. Admin. & Superv.*, **15**, 117–26 (Feb., 1929).—The writer contends that teachers should participate in testing programs. Tables are given showing the types and frequency of errors made by teachers in scoring standard tests. Relations of intelligence of scores to type and frequency of error included. It is shown that training is needed on the part of the teacher to enable her to efficiently give both standard achievement tests and intelligence tests. A method for training teachers in the use of these instruments is suggested. Bibliography included. S. R. P.

An Annotated List of Manuals and Guides for Observation, Participation, and Supervised Student Teaching. A. R. MEAD. *Educ. Admin. & Superv.*, **15**, 47–51 (Jan., 1929).—A list prepared for the use of instructors, directors of training and supervising teachers in their work. Comprises annotations on twenty-two manuals and handbooks. S. R. P.

An Improvement Card for Student Teachers. W. C. TROW AND F. MCLOUTH. *Educ. Admin. & Superv.*, **15**, 127–33 (Feb., 1929).—A short review of previous score cards made for purposes of self-rating or rating by supervisor.

A detailed and carefully arranged score card for the use of the supervisor is presented, valuable features of which are: provision for definite statements concerning wise or poor procedure on the teacher's part and the very detailed nature of the analysis of the teaching procedure. An extensive bibliography is given. S. R. P.

The Reform of Teacher Training in Vienna. M. H. SIEGEL. *Educ. Admin. & Superv.*, **14**, 543–54 (Nov., 1928).—A review of teacher training in Austria and Vienna before the educational reform beginning in 1918; and a discussion of the present teacher-

training program. The relation of political forces to the movements in education. Descriptions of curricula and courses, including service work of the training schools.
S. R. P.

Opportunities in Summer Schools—1929. A. HUMPHREY. *J. Nat. Educ. Assoc.*, **18,** 123–30 (Apr., 1929).—In this compilation are given the names, the length of term or terms of summer schools with dates, last year's enrolment and special features of the principal colleges, universities, and normal schools of the U. S. A. A. E. C.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Junior Metallurgist.

Applications for junior metallurgist must be on file with the Civil-Service Commission at Washington, D. C., not later than June 4th.

The examination is to fill vacancies occurring in the Federal classified service throughout the United States.

The entrance salary is $2900 a year. Higher salaried positions are filled through promotion.

The duties will consist of general metallurgical work connected with the fabrication of manufactured articles, either ferrous or non-ferrous; general metallurgical work including process control, physical testing of metallurgical materials or ores, microphotography and research work on a large variety of metallurgical problems.

Competitors will be rated on practical questions on general metallurgy, chemistry, and elementary physics, and a thesis to be handed to the examiner on the day of the examination.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or from the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

United States Consumption of Primary Tin. The consumption of tin in the United States is so large that the annual imports amount to about one-half of the world's production of that metal, according to the United States Bureau of Mines, Department of Commerce. As the result of a canvass made to ascertain the amount of tin consumed for different purposes in the United States during 1927, the Bureau found that 24,527 long tons of primary or virgin tin were used in the manufacture of tin plate and terne-plate, accounting for 35.65 per cent of the total consumption of primary tin in the United States in that year. Next in order of magnitude as a consuming factor is solder, which required 13,734 long tons, or 19.96 per cent of the total. The manufacture of babbitt required 8705 long tons, and foil and collapsible tube consumed 6903 long tons. The results of the Bureau's inquiry, wherein effort was made to eliminate figures relating to secondary tin, account for 68,797 long tons of primary tin, a quantity equivalent to 96.7 per cent of the imports in 1927. The results of this canvass, based on reports from 1050 concerns, are tabulated in Information Circular 6084, "Consumption of Primary or Virgin Tin in the United States," by J. B. Umhau, copies of which may be obtained from the United States Bureau of Mines, Department of Commerce, Washington, D. C.—*Chem. Age* (*Mo. Metallurgical Section*), **20,** 22 (Mch. 2, 1929).

Local Activities

Through these columns, the JOURNAL desires to render a two-fold service.

1. Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. Providing an exchange column for positions. That is: (1) any teacher who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed, however, the necessity for such action will be largely obviated.

Western Reserve University. Western Reserve University announces that Professor B. Smith Hopkins of the University of Illinois, well known for his discovery of illinium and work in the rare earths, will be the visiting professor in the Department of Chemistry for the forthcoming Summer Session, June 24th–August 2nd.

Professor Hopkins will give two series of lectures, the first on the "Inorganic Chemistry of the Less Familiar Elements and Their Relation in the Periodic System." This course deals with those elements which are passed over hurriedly or neglected entirely in the usual course in inorganic chemistry. The discussion will cover the available minerals, sources of supply, extraction and purification, principal and commercial uses, recently discovered elements, and unfilled spaces in the periodic table. Professor Hopkins will give a second course in "The Teaching of Chemistry" which will include a series of discussions on the problems encountered in the teaching of chemistry.

In addition to the usual undergraduate course in chemistry, Professor H. P. Lankelma will offer a course of lectures on "Stereochemistry, the Carbohydrates and Proteins." Professor H. S. Booth will offer a course, including both lectures and laboratory, in Chemical Microscopy. This is a general course involving the use of the microscope and its accessories in chemical research and the application of microchemical methods, including micro-qualitative analysis, to chemical problems. Numerous industrial applications will be illustrated in the lectures. The students will have an opportunity to receive training in photo-micrography and ultra-microscopy, two phases of the subject not commonly offered in an elementary course. The laboratory in chemical microscopy is excellently equipped with chemical microscopes and complete sets of accessories. Opportunity is offered for advanced laboratory practice in inorganic chemistry, organic chemistry, qualitative and quantitative analysis, physical chemistry, chemical microscopy, and electrochemistry. The laboratory offers special facilities for research in the study of gases, their preparation and purification, and measuring of certain of their physical constants; for work in physical and electrochemistry, organic chemistry, and chemical microscopy.

Medical College of Virginia. The Chemical Foundation has recently made a three-year grant to aid the coöperative research between the departments of chemistry and medicine at the Medical College of Virginia. This work is well under way.

Columbia University. On March 26th the DeLamar lecture under the title "Food and Health" at the Johns Hopkins University School of Hygiene was given by Dr. Henry C. Sherman, Mitchill Professor of Chemistry in Columbia University.

At the recent General Assembly of the National Chemical Society of Poland, in celebration of the tenth anniversary of its founding, Colonel Marston Taylor Bogert, Professor of Organic Chemistry at Columbia University, was elected an Honorary Member of the Society.

Professor Arthur W. Thomas addressed the Chemists' Club of Worcester, Mass., on April 2nd. The subject of his lecture was, "The Chemistry of Leather Formation."

Colgate University. Dr. H. E. Howe, editor of *Industrial and Engineering Chemistry*, visited Colgate April 11, 1929, and gave one of his interesting talks on chemistry at the regular chapel service. At noon, the chemistry staff and Alpha Chi Sigma gave a luncheon for Dr. Howe. Professor J. F. McGregory, who is on leave of absence this year after a service of forty-five years as head of the department, was a special guest at the luncheon. As it happened to be Dr. McGregory's birthday, the occasion was particularly happy.

The Pennsylvania State College. The faculty and graduate students of the School of Chemistry and Physics gave a reception for Dr. Frank Whitmore of Northwestern University, on February 28, 1929, at the Lambda Chi Alpha House. Dr. Whitmore is to take up his duties here as dean on July 1st. He succeeds Dr. Gerald L. Wendt who has been appointed as Assistant to the President in charge of research development in the college.

The Phi Lambda Upsilon, honorary chemical fraternity, recently had an open meeting at which Dr. G. W. Sargent gave an address on steel. Dr. Sargent has had many years of experience in the steel industry and his address was very interesting and instructive. He dealt particularly with the early history of the iron industry in central Pennsylvania and with some of the earlier developments in the crucible steel industry.

The Pennsylvania Academy of Science convened at Penn State on March 29th and 30th. Two papers were presented by members of the chemistry staff; the first, "Modern Pictures of Chemical Combination," by Dr. W. P. Davey, professor of physical chemistry, and the second, "Teaching of Physical Chemistry," was presented jointly by Dr. Davey and Professor Lisse of the department of agricultural and bio-chemistry. Dr. F. W. Kern, dean of the graduate school, had general charge of the sessions.

Construction work on the addition to the Pond Memorial Laboratory is proceeding rapidly and it is expected that the building will be occupied next fall.

The University of Pittsburgh. Professor Silverman addressed the Sigma Xi Association at Columbia University at a banquet held at the Faculty Club of Columbia, Thursday evening, May 2nd. His topic was "The Romance of Glass."

The Ohio State University. The Eastern Inspection Trip for Chemical Engineers, required of all third- and fourth-year students in this curriculum, extended from April 22nd to 27th. These trips are intended to give to the chemical engineering student and advanced student in industrial chemistry some practical knowledge of the magnitude of modern chemical engineering industrial operations from a selected variety of examples, and

to give a practical opportunity for acquaintance with the different branches of the professions of chemical engineering and industrial chemistry in proper perspective, and to receive training in observation, report writing, and discussion. They are strictly educational and are required for graduation in chemical engineering.

Wesleyan University. Prof. Albert Einstein's original manuscript of his paper on a new field theory which attracted world-wide attention a few months ago when it was published by the Berlin Academy of Sciences, is now, according to *Science Service*, a treasured possession of Wesleyan University. This announcement was made recently by Dr. James L. McConaughy, president of the university, who stated that it would be preserved in the Olin Library.

The manuscript was presented to the University by George W. Davidson and Albert W. Johnston, New York financiers. Mr. Davidson is president of the Board of Trustees of Wesleyan University. Mr. Johnston is also a trustee.

Mr. Davidson negotiated for the manuscript with Mr. Einstein through his Berlin representative immediately following its publication, and succeeded in getting it for a sum that has not been announced. Prof. Einstein will use the proceeds for welfare work among university students in Germany.

The manuscript of the relativity theory was presented by Prof. Einstein to the Zionist University at Jerusalem, while the manuscripts of his later works, preceding the field theory, were purchased by Baron Rothschild of London, who presented them to the Einstein Institute at Berlin.

J. T. Baker Chemical Co. Analytical Research Fellowship. The J. T. Baker Chemical Co., eastern division, recently established a research fellowship in analytical chemistry of the value of $1000 a year. The first award of this fellowship has been made to Mr. Charles H. Greene for the year 1929–30 to work on "The Solubility of Precipitates in Dilute Solutions of the Precipitant" under the direction of Professor G. P. Baxter at Harvard University. Mr. Greene is a graduate of Haverford College (1926), and received the Master of Arts degree from Harvard University in 1927.

The committee of award was composed of N. Howell Furman, Princeton University, *Chairman;* Philip E. Browning Yale University, *Secretary;* Gregory P. Baxter, Harvard University; E. M. Chamot, Cornell University; H. A. Fales, Columbia University.

For those interested in filing an application another year, an outline of the aims and requirements of this fellowship are herewith given.

1. The fellowship shall be known as the J. T. Baker Chemical Company Eastern Fellowship for research in analytical chemistry.

2. The fellowship will be granted to an advanced student in analytical chemistry for study in an institution conferring the doctor's degree in chemistry in the New England States, New York, Pennsylvania, New Jersey, Delaware, or Maryland.

3. The objects of this fellowship are to develop fundamental research in the quantitative estimation of inorganic components as distinguished from routine application of established methods; to encourage such research; and, in general, to develop reliable, precise chemical measurement.

4. The holder of this fellowship will receive $1000 annually. Ordinarily, the fellowship will not be awarded to the same candidate for two years in succession.

5. The fellowship may begin in the autumn or in a summer session and each candidate will be expected to devote at least nine months to the research.

6. A candidate for this fellowship must possess the following qualifications:

(*a*) A Bachelor's degree or its equivalent.

(*b*) A broad training in the fundamental branches of chemistry including inorganic, organic, and physical chemistry as well as qualitative and quantitative analysis.

7. In awarding this fellowship preference will be given to those who have already had experience in research in chemistry.

8. Application for the academic year 1930–31 should be made before March 1st to the Chairman of the Committee and should include the following information:

(*a*) Age
(*b*) Degrees
(*c*) Previous training in chemistry
(*d*) Outline of proposed problem
(*e*) Name of person under whose direction work is to be done. (It is understood that the applicant will ascertain the requirements of the institution where the work is to be done. Consideration of the applications will be facilitated if five copies are sent.)

9. Within a month after the end of the academic year for which the fellowship is awarded the holder of the fellowship shall send to the committee and to the J. T. Baker Chemical Co. a report of work accomplished during the year, and it is expected that the results of the work will be published in the Journals of the American Chemical Society within a reasonable time.

10. Information on points not covered by the articles above may be obtained from the committee.

McKinley High School, Washington, D. C. In the *Tech Life* for April 15th the following note of interest appeared:

The equipment of the chemical laboratory was announced as completed during the last week and was thrown open for public inspection immediately thereafter. Upon being interviewed, Dr. Mattern, head of the chemistry department, declared that after many unavoidable delays, Tech now had a laboratory with which those of few colleges can compete. He compared this new achievement with the first laboratory at Tech in the early days of the century, when the entire equipment consisted of a table, a few instruments, and a "slop jar."

Room Holds Nine Tables. The new laboratory has nine large, tile-topped tables with depressions in the top to hold the bottles of chemicals, thus eliminating the cumbersome racks and giving a clear view across the entire room. There is equipment for over 150 regular experiments and for many more if necessary.

All Fixtures Plated. The plumbing is of iron and all fixtures are chromium-plated. There are four hundred and eighty lockers for the students. There is also a special draft system of ventilation completely insuring a plentiful supply of air and making it impossible for dangerous gases to accumulate.

Supply Room Well Stocked. Besides the main laboratory, there is a supply room provided with hundreds of chemicals and a large table similar to the ones in the laboratory for special work, an office, a room for the manufacture of H_2S, a weighing room for delicate experiments, and a classroom seating fifty. This room is equipped with a table, and a stereopticon machine, which is a novel addition and which will facilitate the teaching of practical and theoretical work.

Library Unusually Complete. Another feature is a complete library of chemical works gathered in over twenty-five years' study along this line by both Dr. Mattern and Mr. Marsh. These books are always available to students who wish to delve further into the mysteries of that science.

The instructors also have on display autographed photographs of Ira Remsen, considered the world's greatest chemistry teacher, Charles E. Monroe, and Professor Pond, also famous in their profession. These men were teachers of either Dr. Mattern or Mr. Marsh.

Light Appeals to Visitors. Numerous visitors have commented on the sensation of brightness and freshness which confronts one on first entering the

chemistry rooms. The completion of this laboratory marks a notable step toward the finishing of the equipment for the new McKinley.

Oregon Section A. C. S., Sponsors High-School Chemistry Contest. The Oregon Section of the A. C. S. is undertaking to create interest both among students and teachers of chemistry by offering a prize to be awarded to the Oregon high school, either public or private, whose team submits the best average examination in this subject. The committee in charge, of which Prof. John Fulton is chairman, has endeavored to communicate with teachers in all the high schools where chemistry is offered.

For those who are interested in such a project we are herewith printing the rules of the contest for 1929:

1. **Number of students composing a team:** High schools having 24 or **fewer** students enrolled in second semester chemistry class on March 25 shall enter a team of 3 students. High schools having 25 or **more** students enrolled in the above class on the above date shall enter one additional member for each **full quota** of 10 students above 15, thus requiring, for example, a team of 5 for an enrolment of 35 to 44.
2. **Selection of students:** To be made by the high-school teacher of chemistry from those who on March 25 are enrolled in second semester chemistry class.
3. **Notification of personnel of team:** The names of the members of the team shall be submitted by the teacher or principal to the chairman of the committee on or before Monday, April 15.
4. **Basis of award:** Upon the results of a written examination to be held at each competing high school on Friday, May 10, the high school obtaining the highest team average being considered the winner.
5. **Scope of examination:** One year of high-school chemistry.
6. **Form of examination:** To consist of three parts, each of equal value: namely, (1) general principles of elementary chemistry, including problems; (2) relations of chemistry to natural materials and phenomena, and technical applications; (3) experiments in chemistry, including problems.
7. **Prize and honors:** The prize consists of a trophy suitably engraved to be presented at the commencement exercises of the winning high school by a representative of the Oregon Section of the American Chemical Society, and to become the permanent property of the winning high school. No other prize is to be awarded, but announcement may be made of high schools meriting honorable mention.

Cincinnati Section, A. C. S. The 306th meeting of the Cincinnati Section of the American Chemical Society was held in the auditorium of the chemistry building of the University of Cincinnati at 8.00 P.M., Wednesday, April 10, 1929.

This was a joint meeting of the Cincinnati Section with the Cincinnati Professional Chapter of Alpha Chi Sigma, the national professional chemical fraternity. Alpha Chi Sigma furnished the speaker, Frank B. Wade of Indianapolis, who addressed the meeting on the subject "Man-Made Gems."

Dr. Wade is head of the chemistry department of Shortridge High School, Indianapolis. He has made the study of natural and synthetic gems his lifelong hobby and he is an authority of world-wide repute on the subject. He has spoken by invitation before several international associations of jewelers and gem merchants. His lecture dealt with the history, chemistry, manufacture, and detection of synthetic gems and it was illustrated with lantern slides.

Lexington Section, A. C. S. The 134th regular meeting of the Lexington Section of the American Chemical Society was held at the University of Kentucky, Tuesday, April 16th, at 4.00 P.M.

Dr. L. C. Lindsley of Columbia University spoke on "Industrial Chemical Microscopy." Dr. Lindsley has spent many years in developing this material and illustrated his lecture with lantern slides. Much was learned of the progress being made in this somewhat unfamiliar field.

New England Association of Chemistry Teachers. The 115th Meeting of the N. E. A. C. T. was held Saturday, April 20, 1929, at the Warren Harding High School, Bridgeport, Conn.

PROGRAM

MORNING SESSION

10.00 Choice of trips to:

1. The Remington Arms Co. Laboratory and Shot Tower
2. The Bridgeport Brass Co. Laboratory and Works

3. The Heppenstall Forge Co. Large Steel Forgings

AFTERNOON SESSION

1.30 "Welcome to Warren Harding," MR. RAYMOND WALKER, Vice Principal of Warren Harding High School

1.45 "Some Interesting Applications of Chemistry in the Bridgeport Industries," DR. JOHN F. HUTCHINSON

2.30 "Chemistry in the Brass Business," MR. JOHN L. CHRISTIE

3.00 Business Meeting

3.30 Inspection of Warren Harding High School

American Philosophical Society. Scientists from all parts of the country assembled in Philadelphia from April 18th to 20th when America's oldest learned society, the American Philosophical Society, held its annual general meeting. Founded in 1727 by Benjamin Franklin, the society occupied a building in the famous Independence Hall group before the American revolution. It was in this same historic building, in the same rooms in which Franklin himself presided over the meetings, that the recent sessions were held.

All branches of science were represented in the reports of new researches made. Among the speakers, according to *Science Service*, were DR. HARLOW SHAPLEY, director of Harvard College Observatory; PROF. HENRY NORRIS RUSSELL, Princeton University astronomer; DR. GAYLORD P. HARNWELL, Princeton physicist; DR. JAMES BREASTED, director of the Oriental Institute of the University of Chicago; DR. LEON LEGRAIN, curator of the University of Pennsylvania Museum; DR. ALAN ROWE, famous for his excavations of the ancient city of Beisan; DR. GEORGE A. BARTON, professor of Semitic languages at the University of Pennsylvania; DR. FREDERICK TILNEY, professor of neurology at Columbia University; DR. I. P. TOLMACHOFF, curator of the Carnegie Museum of Pittsburgh; DR. GEORGE W. CRILE, Cleveland surgeon; and DR. ALES HRDLICKA, Smithsonian Institution anthropologist.

"Floating University" Idea Opened to Summer School Students and Teachers. A series of six College Tours to Europe, announced recently by Dr. James E. Lough, at 285 Madison Avenue, New York City, opens his "floating university" idea this summer to students and teachers, many of whom are unable to join the annual College World Cruise in the winter. Delphi, Athens, Rome, and Venice now serve as classrooms for students of ancient history, for on each tour, college and professional courses in art, literature, economics, geography, and history are given by well-known professors and carry full academic credit.

"The plan provides a summer school in Europe similar in every essential to those in American universities," said Dr. Lough, president of the world's first Floating University in 1926–27 and Director of College Tours, "with the addition that the students do field work under faculty supervision during the College Tour as a part of each course.

"The itineraries have been arranged as backgrounds for the subjects taught. Students of French, for example, cross on French ships and reside at Grenoble University, while art students visit the important museums of England, France, Italy, Holland, Austria, and Germany under faculty leadership.

"Previous university tours and cruises have demonstrated that extensive travel and systematic study may be combined to the great advantage of each," continued Dr. Lough, who organized the College World Tour now in Japan in connection with the 1929 World Cruise of the "Belgenland." "The students see more than when traveling independently or on mere sightseeing tours, and at the same time the study of such subjects as economics, history, or French is vitalized by direct contact with the problems."

The cost of these travel study tours is no higher than other moderately priced tours without this educational feature. Thus the price of the French Residence Tour with 52 days of intensive study in French literature and conversation is only $485.00. Students and teachers who desire to register for this summer school abroad and to receive college or professional credit for their courses should communicate with Dr. Lough.

Parke, Davis & Company. Dr. Oliver Kamm, chief of the Chemical Research Division of Parke, Davis & Company and recipient of the 1928 $1000 prize of the A. A. A. S., was elected president of the Michigan Academy of Science, Arts and Letters at its annual meeting held at the University of Michigan, Ann Arbor, during the third week in March.

The Michigan Academy is officially affiliated with the American Association for the Advancement of Science, and its membership is made up largely of Michigan scientists, particularly those engaged in teaching and research work at the University of Michigan and other institutions of higher learning in the state.

Dr. Kamm was formerly on the chemical teaching staff of the University of Michigan, leaving there in 1916 to accept similar duties at his alma mater, the University of Illinois, at which school he advanced to the position of associate professor. In 1920 he gave up teaching work to assume charge of the Chemical Research Division of Parke, Davis & Co.

Motion Picture Films of Mexican Oil Fields. "Through the Oil Fields of Mexico" is the title of a new educational motion picture film prepared by the Department of Commerce, through the U. S. Bureau of Mines in coöperation with one of the large oil-producing companies, and now released for distribution. The film, which is in three reels, visualizes the drilling of oil wells in the Mexican jungles and depicts the various stages in the transporation, storage, and refining of petroleum in the sister republic to the south. Many picturesque scenes illustrating Mexican life and customs and numerous striking scenic effects appear in the film, which was produced under the direct supervision of the Bureau of Mines. The location of the principal Mexican oil fields is made plain by the use of specially drawn maps.

The first scenes show what has been called the "Hill of Tar," where the seeping of oil through the surface first called attention to the petroleum possibilities of Mexico. Next follow scenes of the Cerro la Pez well, the first commercial oil well in Mexico, which attracted the pioneers of the industry. A glimpse of the first oil-burning locomotive to be operated in that country is shown.

Views are presented of the Cerro Azul camp on the site of one of the richest oil pools of history. Here it was that in 1916 the Cerro Azul No. 4 well was drilled in, probably the most spectacular and best-known oil well in the world.

Especially attractive are the scenes showing the snow-capped peak of Orizaba, towering to a height of 18,000 feet, and the mountains, including the famous Popocatapetl, overlooking the Mexican capital. Quaint bits are introduced showing typical Mexican village markets; Mexican women carrying water jars upon their heads; the use of the humble burro for transport, etc.

It is pointed out that one and a quarter billion barrels of oil have been produced in Mexico and that one and one half billion dollars, much of which is American capital, have been spent by the industry in the recovery and handling of Mexican petroleum.

Copies of the film "Through the Oil Fields of Mexico" may be obtained for exhibition purposes by addressing the Pittsburgh Experiment Station of the U. S. Bureau of Mines, Pittsburgh, Pa. No charge is made for the use of the film, but the exhibitor is asked to pay the costs of transportation both ways.—*Science*, **69**, 290 (Mch. 15, 1929).

Recent Books

The Ordinall of Alchemy. THOMAS NORTON of Bristoll. Being a facsimile reproduction from "Theatrum Chemicum Britannicum" with annotations by Elias Ashmole. With introduction by E. J. Holmyard, M.A., D.Litt., F.I.C. Edward Arnold and Co., London, 1929. viii + 125 pp. 13.75 × 21.75 cm. 10s. 6d. net.

The readers of the JOURNAL OF CHEMICAL EDUCATION who attended the last Detroit meeting of the American Chemical Society have pleasant recollections of the remarks of the late Dr. Edgar F. Smith, upon Elias Ashmole's "Theatrum Chemicum Britannicum," of which he exhibited a rare copy at that time. They will, therefore, especially welcome the present facsimile reproduction of that part of the text, illustrations, and notes of Ashmole's famous work which pertain to Thomas Norton's "Ordinall of Alchemy." The story of Norton's life and alchemistic pursuits is interestingly told in his introduction by Dr. Holmyard who, we feel certain, was prompted to undertake the publication of a new edition of this old classic not only by his historical attachments but also by a loyal interest in the career of a fellow townsman and chemist of five centuries ago.

The setting forth of the secrets of alchemy in poetic form was first begun by the old Greek alchemists of whose poems upon the sacred art several specimens have come down to us. The practice was imitated by the later adepts who wrote in medieval Latin and in the vernacular of the different European nations. These later poems are in large measure paraphrases of the allegorical language and pious mysticism of the older Greek alchemists whose obscure descriptions of processes, replies to critics, invocations, and prayers are all reproduced with but little variation of matter or form (see reviewer's translation and commentary upon the Greek alchemistic poem of Theophrastus, *Scientific Monthly*, **1920,** p. 193). Norton's "Ordinall," while resembling in certain places previous poems upon alchemy, has an additional interest in that it furnishes materials of a biographic character and also gives a commentary upon the works of older writers, of whom Anaxagoras, Democritus, Aristotle, Geber, Avicenna, Raymond Tully, Albertus Magnus, Roger Bacon, and many others are mentioned. The need of scrupulous care in every minute detail for preparing the stone and elixir is emphasized, the neglect of any one of which was the cause

> "Wherein manie of Gebars Cookes
> Deceived were, though thei be wise in Bokes."

Almost as interesting as Norton's work itself are the quaint "Annotations and Discourses" upon the poem by Elias Ashmole, the faithful antiquary to whose zeal and industry we are indebted for the publication of the "Ordinall" and other scattered manuscripts which make up his "Theatrum Chemicum Britannicum." There are many of these old manuscript collections still in existence [see reviewer's article upon An Old Colonial Manuscript Volume Relating to Alchemy, THIS JOURNAL, **5,** 1583–90 (Dec., 1928)] and it is hoped that Dr. Holmyard's new edition of Norton's "Ordinall" will stimulate an interest among chemists in this and similar other ancient English works.

The publishers' reproduction of the old text and beautiful engravings of Ashmole's edition of the "Ordinall" is well executed and the book is one which will be an ornament in every chemical library. It is warmly recommended to all who are

interested in the early history of chemistry.

C. A. BROWNE

BUREAU OF CHEMISTRY AND SOILS
WASHINGTON, D. C.

Fundamentals of Chemistry. CARL WILLIAM GRAY, Head of Chemistry Department, Hollywood High School, Los Angeles, CLAUDE W. SANDIFUR, Principal of Lankershim High School, Los Angeles, and HOWARD J. HANNA, Head of Physics Department, Los Angeles High School. Revised and enlarged edition. Houghton Mifflin Co., Boston, Mass., 1929. xiv + 650 pp. 202 figures. 12.5 × 18.75 cm. $1.80.

This is a high-school text and as such deals mainly with general inorganic chemistry. In the later chapters, however, there is given an elementary account of organic chemistry and there are chapters on "Common Fuels," on "Petroleum and Its Products," on "Soap," "Paints, Varnishes, Lacquers," "The Chemistry of Clothing," "Chemistry in Agriculture," and "Colloids."

Thus, we have in the first two-thirds of the book a presentation of facts and laws and theories and in the last third numerous applications of chemistry. The order in which the work is given appeals to the reviewer as natural and suitable for beginning students. It might perhaps be still further improved by omitting the second chapter, which deals with "Matter and Energy" and then teaching the content of that chapter as occasion required in connection with the work as it progressed. The early attack takes up some familiar metals and a few less common ones and proceeds to inquire into the action of the atmosphere upon them, thus leading up to the subject of oxygen in a natural way. The atmosphere and the other gases in it come next, then "metallic oxides" are studied. After this, water is taken up and studied first from the physical, then from the chemical viewpoint. Hydrogen naturally comes next. A chapter on subatomic structure follows and dissociation in water solution is then treated. The early introduction of this latter subject is a distinctive feature of this text. "Hydroxides," "Valence and Formulas," and "Equations" are next in order and then the systematic study of the various elements of the periodic chart follows. This descriptive work is interspersed with chapters on important chemical principles such as "Chemical Equilibrium and Mass Action."

Enough of an account of the order of events has been given to show that the authors have an original method of treatment. Many helpful illustrations and diagrams are included.

One misses the use of the Avogadro law in the determination of molecular weights, the authors having perhaps given up the use of molal volume with beginning pupils as a bad job. Atomic weights are similarly handed to the pupil ready made. The reviewer may be clinging to a forlorn hope but he still tries to put over a comprehension of these things.

While one may not agree with all parts of this text it is one that must command great respect from all chemistry teachers and we would suggest that all live high-school chemistry teachers should try to become acquainted with it.

F. B. WADE

SHORTRIDGE HIGH SCHOOL
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Organic Syntheses. Volume IX. An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals. JAMES B. CONANT, *Editor-in-Chief*, with ROGER ADAMS, H. T. CLARKE, HENRY GILMAN, C. S. MARVEL, AND F. C. WHITMORE. John Wiley and Sons, Inc., New York, 1929. v + 108 pp. 15 × 23 cm. $1.75.

The ninth volume of this excellent work prepared and presented under the editorial guidance of Professor Conant and his co-workers, maintains in every way the high standard set by the earlier volumes.

Accurate and explicit directions are presented for the synthesis of the following compounds:

Acid Ammonium-*o*-Sulfobenzoate, *dl*-Alanine, Ammonium Salt of Aurin Tricarboxylic Acid, Anisile, Benzoyl Piperidine, *p*-Bromphenacyl Bromide, *o*-Bromotoluene, *n*-Butyl Carbamate, *n*-Butyl-*p*-Toluenesulfonate, *n*-Butyryl Chloride, *o*-Chlorobenzoyl Chloride, Cyanoacetamide, Ethyl Cinnamate, Hydrocinnamic Acid, Iodobenzene, Levulinic Acid, *l*-Menthone, Mercury Diphenyl, Methylene Bromide, Monochloromethyl Ether, β-Naphthol Phenylaminomethane, *o*-Nitroaniline, Nitrostyrene, Pentamethylene Bromide, γ-Phenoxyl Bromide, Phloroglucinol, Pyrrole, *o*-Sulfobenzoic Anhydride, *ac*-Tetrahydro-β-Naphthylamine.

Each succeeding volume of this most useful book only serves to emphasize its great value to those engaged in the practice of organic chemistry. Chemists everywhere owe a lasting debt of gratitude to the men who first conceived this splendid idea and under whose guidance and editorial direction this work has gone forward in ever-increasing usefulness.

It is pleasing to note the wide distribution of contributors to this volume, and it is to be hoped that in the future many chemists who have not as yet aided in the work, will see fit to make contributions to this most creditable publication. In this way, its value to chemists will still further be enhanced.

JOHN J. DONLEAVY
YALE UNIVERSITY
NEW HAVEN, CONN.

The Fundamentals of Quantitative Analysis. WALTER C. BLASDALE, Ph.D., Professor of Chemistry in the University of California, at Los Angeles. Third edition. D. Van Nostrand and Co., New York, 1928. vi + 403 pp., 61 figures. 13.5 × 21.5 cm. $3.75.

In the revision of this text the author seems to have in mind as the main object or purpose the correct correlation of theory and laboratory manipulation, since he states that it is only through a definite knowledge of chemical principles that the analyst can do intelligent work, that the simple mechanical performance without knowing the reason for each step is not worthy of the term "Quantitative Analysis."

The usual divisions of the subject matter, gravimetric and volumetric analysis, have been made. The section dealing with gravimetric analysis has been treated in four chapters. These chapters deal with the formation of an insoluble gas, the formation of an insoluble solid or precipitate, extraction processes and partition processes. The part dealing with volumetric analysis has the usual divisions—precipitation, neutralization, and oxidation and reduction.

This text is quite a departure from the general run of texts on quantitative analysis in regard to the amount of space devoted to theoretical discussion. Not only are the chemical principles involved in the various determinations discussed very fully but the theory underlying all the common mechanical operations is explained at some point in the text. He seems to have realized what too many authors apparently have not taken into consideration—that a course in quantitative analysis is really composed about equally of theoretical discussions of the chemical principles and mechanical operations involved and actual laboratory determinations, and not simply a collection of simple laboratory instructions. His discussion of these points is very good.

About the usual category of laboratory determinations are included in the text. However, there is an exception in that iron is determined by electrolysis instead of in the usual gravimetric way. The only change in the volumetric part is the placing of the precipitation processes first instead of neutralization as is usually done. Due to the simplicity of these processes, this may be advisable.

In order to further illustrate the subject matter under consideration, several chapters have a list of questions and problems appended. While this may be helpful, it cannot take the place of a course in chemical calculations.

In several places the author is lax in his use of terms. As an example of this he calls the color of potassium dichromate red.

There are several typographical errors which should be corrected.

From the standpoint of exposition of

chemical principles and theory of mechanical operations, the text is very satisfactory.

J. T. DOBBINS
UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, N. C.

Reference Book of Inorganic Chemistry. WENDELL M. LATIMER, A.B., Ph.D., and JOEL H. HILDEBRAND, B.S., Ph.D., University of California. The Macmillan Company, New York City, 1929. viii + 442 pp. 47 figures. 14 × 21.5 cm. $3.75.

This book provides a volume of descriptive chemistry to supplement the "Principles of Chemistry" by Hildebrand, and the "Course in General Chemistry" by Bray and Latimer.

The contents comprise twenty-two chapters and a glossary devoted to the descriptive chemistry of the elements and their compounds, and nineteen appendices. In the first three chapters, hydrogen, the inert gases, and oxygen, in the order named, are discussed and then, beginning with the alkali metals, the various groups and sub-groups of the periodic system. In the appendices will be found such material as Standard Oxidation-Reduction Potentials, Free Energy Values and Their Use, Ionization of Strong Electrolytes, The Electron Structure of the Elements, etc.

As will be noted the arrangement does not conform to that of the usual inorganic chemistry texts. A large amount of material is presented and it is left to the instructor to make his own selection of subject matter and to present it in the order which most appeals to him. The inclusion of atomic properties and physical constants in tables, and other statistical material in the appendices permits of a clear, concise, and interesting discussion of chemical properties and relationships in the text.

Modern concepts of chemistry are employed throughout the book. The relationship of chemical properties to atomic structure and size is presented clearly and can be easily understood by the freshman student. The formulas of most compounds are given in terms of the Lewis-Langmuir theory of valence. The continued illustration of these theories is to be commended for too often they are presented in an isolated chapter and the student fails to grasp their significance.

It is perhaps to be regretted that, in order to keep the cost of the book at a low figure, the authors have felt obliged to omit references to original sources of material.

The book is particularly free of typographical errors and the tables show evidence of careful checking and proofreading.

This volume should appeal to a wide range of interests. In addition to its value as a text it can be heartily recommended to the advanced student and to the teacher of inorganic chemistry for reference use.

G. C. CHANDLEE
THE PENNSYLVANIA STATE COLLEGE
STATE COLLEGE, PENNSYLVANIA

Chemical Publications, Their Nature and Use. MELVIN GUY MELLON, Ph.D., Associate Professor of Analytical Chemistry, Purdue University. McGraw-Hill Book Co., New York, 1928. viii + 253 pp. 3 cuts. 14 × 20.5 cm. $2.50.

The book has a three-fold object: to sketch the development of chemical publications from early times, to give a comprehensive view of available sources of chemical information and their classification, and to serve as a laboratory manual for students who wish to learn the methods of making searches and writing reports. It is intended as a textbook for an undergraduate course in chemical literature, for one semester, one hour a week.

After an introductory chapter on early chemical literature, four chapters, comprising 54 pages, are devoted to original sources: periodicals, institutional publications, patents, and miscellaneous. The journals are described and listed in divisions according to their chief interest.

The nature of a patent is discussed with an actual patent as an illustration, patent publications are listed and the methods of making a search described.

Three chapters are devoted to secondary publications, abstract journals, index and review serials, bibliographies, handbooks, encyclopedias, monographs, and textbooks. The student is told what is in these and how to work through them to the original sources.

The third section is the practical part. After some information about technical libraries and their use, a series of problems is given. These are to be assigned to students as laboratory experiments to be reported on at the next meeting of the class. They begin with simple questions and lead up to the preparation of a bibliography on such things as artificial silk, aluminum alloys, and protective coatings.

The book is well adapted for class instruction, for which it is intended, and will be useful to chemists who have had inadequate instruction in library methods, and that means the most of us.

E. EMMET REID

THE JOHNS HOPKINS UNIVERSITY
HOMEWOOD, BALTIMORE, MD.

Salts, Acids, and Bases: Electrolytes: Stereochemistry. PAUL WALDEN, Professor of Chemistry, University of Rostock. McGraw-Hill Book Company, Inc., New York City, 1929. iii + 397 pp. 26 figures, 1 plate. 15 × 23 cm. $4.00.

No less than the author, the translator of these "Baker" lectures at Cornell, is to be congratulated on a workmanlike performance. Dr. L. F. Audrieth has produced an eminently readable English version containing few of those grotesque constructions into which inexperienced or careless translators easily fall.

Professor Walden has treated three separate fields of chemical study which have especially engaged his interest and to two of which he has made distinguished contributions. The history of the concepts acid, base, and salt is almost coextensive with the history of chemistry, at least until about a hundred years ago, and to follow with the author the fluctuating meanings of these words over the course of centuries is to sympathize much more intelligently with the perplexities of the alchemist and the iatrochemist, pioneers in the chemical jungle. Such a survey gives us also an historical background which we sorely need today when the air is full of proposals for redefinition of some of these most fundamental terms.

With regard to the naming of bases and acids, the author discusses critically the proposals of Franklin, Lewis, Brönsted, Germann, and others, and his conclusion is embodied in the following query (p. 159): "Would it not be better, in place of the more or less sweeping generalizations, to retain the old-established names and concepts with their hydrogen and hydroxyl ions based upon the behavior of aqueous or water-like electrolytic solutions, and to introduce *special* terms for the exceptional cases dealing with new types of solvents?"

In the sections that follow, Walden's own work on the physical properties of non-aqueous solutions is reviewed. Among the very numerous interesting results reported the following may be especially noted. When two salts such as NR_4Cl and NR_2H_2Cl are compared in a variety of solvents, it is found that the apparent dissociation is nearly the same in water and in alcohol, but that in acetone, methylene chloride, chloroform, and ethylene chloride, the former salt appears to be respectively, 10, 170, 800 and several thousand times as much dissociated as the latter. This is correlated with the behavior of the strongest acids, which all show practically complete dissociation in water or alcohol, but gradually change into weaker and weaker electrolytes as less and less basic solvents are used.

An illuminating discussion of the famous Walden Inversion concludes the book. This volume is to be recom-

mended chiefly to those readers who have a special interest either in historical chemistry, the electrochemistry of non-aqueous solutions, or in molecular rearrangements. The type is exceptionally large and clear, and the paper and binding of excellent quality.

NORRIS F. HALL

HARVARD UNIVERSITY
CAMBRIDGE, MASS.

Identification and Properties of the Metals and Non-Metals. J. E. BELCHER AND J. C. COLBERT, Assistant Professors of Chemistry in the University of Oklahoma. The Century Company, New York City, 1929. xii + 246 pp. 17 illustrations. 21 × 27 cm. $1.75.

The manual is divided into two parts. The first part consists of twenty-eight experiments in general chemistry and covers 117 pages. The second part contains five additional experiments and an introduction to qualitative analysis. The five experiments deal with subjects which the reviewer thinks could be more logically placed in the first part.

The preface sets forth the desire of the authors to "relieve the burdened instructor in grading note-books and at the same time enable the student to attain the right attitude toward his work."

The first part of the manual is very praiseworthy. It deals with experiments on both organic and inorganic substances. Perhaps the name of the volume could be revised with profit. Each experiment contains references to Kendall's revision of Alexander Smith's "General Chemistry." "The authors of this manual have made it impossible for the student to answer all of the questions asked on the experiments without constant use of the textbook in the laboratory." The object and materials to be used are stated at the beginning of each experiment. It is written in a manner that should tend to excite the interest of the student and develop his powers of thought and observation.

A novel feature of the volume is the double report sheets for each experiment. By means of carbon paper which is furnished with the manual, duplicates of report sheets are made. The perforated report sheet is to be torn out and handed in. This lessens the burden of turning numerous pages in grading. At the same time, it allows the student to keep his manual.

The second part of the manual is a very good introduction to the subject of qualitative analysis. The appendix contains a scheme of elementary qualitative analysis, numerous tables, problems, and questions which should be very well received.

Instructors in general chemistry should find this volume a welcome addition to the list of manuals on the subject.

V. T. JACKSON

UNIVERSITY OF FLORIDA
GAINESVILLE, FLA.

Determination of Molecular Weights in the Vapor State from Vapor Pressure and Evaporation Data. E. W. WASHBURN, *Chief*, Chemistry Division, *Bureau of Standards. Research Paper* No. **53,** Department of Commerce. U. S. Government Printing Office, Washington, D. C., 1929. 12 pp. 14.5 × 23 cm. $0.05.

"If one determines at the same temperature the vapor pressure of a substance and the amount of it required to saturate, by aspiration, a measured volume of an indifferent gas, the molecular weight of the substance in the gaseous state is calculable. By employing a reference substance of known molecular weight the measurement of the volume of aspirated gas is unnecessary and the quantities measured have small temperature coefficients. A precision discussion of the method is given. It should be capable of a high degree of accuracy in many cases and is applicable at much lower temperatures than are the methods commonly employed."

M. W. G.

The Sulphoaluminates of Calcium. W. LERCH, F. W. ASHTON, AND R. H. BOGUE, *Bureau of Standards, Research Paper* No. **54,** Department of Commerce. U. S. Government Printing Office, Washington, D. C., 1929. 17 pp. 14.5 × 23 cm. $0.10.

"Two calcium sulfoaluminates have been prepared and their compositions and optical characteristics determined. One of these, having the composition $3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 31H_2O$, is relatively stable in aqueous solutions but is decomposed by solutions of magnesium salts and of carbonates. The other, having the composition $3CaO \cdot Al_2O_3 \cdot CaSO_4 \cdot 12H_2O$, is relatively unstable except in high concentration of hydroxyl ion. It is readily converted to the high sulfate form in aqueous solutions but is decomposed by magnesium salts and carbonates. In sulfate solutions the high form may be produced, but in the presence of a slight excess of magnesium salts or carbonates neither of the sulfoaluminates can continue to exist. In these cases the less soluble magnesium hydroxide and calcium carbonate, respectively, are formed."

M. W. G.

Third Report of Commission on Medical Education. A. LAWRENCE LOWELL, *Chairman.* Office, Director of Study, 215 Whitney Avenue, New Haven, Conn. October, 1928. 70 pp. 14.5 × 23 cm.

This report is the third but not the final of the commission on medical education. The commission has endeavored to present what it believes to be the most important principles that should be emphasized in medical training. The first part of the report is a statement of these principles and the second part is a brief amplification and discussion of them.

The headings of the chapters in each part are: (1) Pre-Medical Education, (2) Teaching in the Medical Sciences, (3) Teaching in Clinical Medicine, (4) General Considerations.

The appendix includes information relative to: (1) The Growth of the Student Body in Secondary Schools and Colleges, (2) Applications for Admission to Medical Schools, (3) Organization of Clinical Teaching, (4) The Teaching of the Practice of Preventive Medicine in the Individual. M. W. G.

Opportunities for Chemists in the U. S. Civil Service. Form 2528. *U. S. Civil-Service Commission.* U. S. Govt. Printing Office, Washington, 1929. 28 pp. 9 × 21 cm.

This booklet is a revised edition of an earlier publication, the revision being based upon recent increases in salaries authorized by Congress. It is now available for distribution.

Record of Current Educational Publications. *Department of the Interior, Bulletin* No. 23. Compiled in the Library Division, John D. Wolcott, *Chief.* U. S. Government Printing Office, Washington, D. C., 1929. 116 pp. 14.5 × 23 cm. $0.20.

Comprising publications received by the Bureau of Education, October–December, 1927, with index for the year 1927.

A Critical Study of Measure of Achievement Relative to Capacity. C. W. ODELL, Assistant Director, Bureau of Educational Research. *Bulletin* No. 45, University of Illinois, Urbana, 1929. 23 × 15 cm. $0.50.

Bulletins of the National Research Council, Washington, D. C., 1929:

No. 67. *The Minimum Protein Requirements of Cattle.* H. H. MITCHELL. 84 pp. 17 × 25 cm. Report of committee on animal nutrition.

No. 68. *Transactions of the American Geophisical Union,* Ninth Annual Meet-

ing, April 26 and 27, 1928, Washington, D. C. 103 pp. 17 × 25 cm.

BOOKS RECEIVED—LIBRARY OF CONGRESS, MARCH 15 TO APRIL 15, 1929

Aita, Antonio, Gli acidi inorganici; solforico, nitrico, cloridrico; fabricazione, macchinari e impianti. Milano, U. Hoepli, 1928. 3 p. l., ix–xiv pp., 1 l., 472 pp. incl. illus., tables, diagrs. 23½ cm.

Asch, Wladislaw, Die silicate in chemischer und technischer beziehung, unter zugrundelegung der seitens der philosophischen fakultät der Universität Göttingen preisgekrönten hexit-pentit-theorie nebst umwandlung derselben in eine allgemeine stereochemische theorie. Berlin, J. Springer, 1911. xv, 409, 1 p. diagrs. 24 cm.

Bagsar, Aaron Bysar, Reduction of metallic chlorides by hydrogen. New York City, 1927. 50 pp., 1 l. illus., diagrs. 23 cm.

Thesis (Ph.D.)—Columbia University, 1928.

Bennett, George Wayland, Adsorption at crystal interfaces. Menasha, Wis., 1928. 1 p. l., 571–581, 1 p. 1 illus., diagrs. 23½ cm.

Thesis (Ph.D.)—Ohio State University, 1927.

Boss, Arthur Evan, Observations on the rare earths; the atomic weight of erbium. Easton, Pa., 1928. 1 p. l., pp. 298–300, 1 l. 23½ cm.

Abstract of Thesis (PhD.)—University of Illinois, 1927.

Campbell, Arthur William, Nitrogen trichloride and unsaturated hydrocarbons. iii. Nitrogen trichloride and diphenyl ketene. Easton, Pa., Mack Printing Company, 1928. 6 pp., 1 l. 24 cm.

Cline, Edwin Louis, Some derivatives of ethylbenzene. Easton, Pa., Mack Printing Company, 1928. 11, 1 p. 23½ cm.

Thesis (Ph.D.)—Johns Hopkins University, 1927.

Craig, David, Nitrogen trichloride and unsaturated ketones, Easton, Pa., Mack Printing Company, 1928. 7, 1 pp. 1 illus. 24 cm.

Thesis (Ph.D.)—University of Iowa, 1928.

Dehnicke, Johannes, Laboratoriumsbuch für die brennerei-industrie. Halle (Saale) W. Knapp, 1928. xi, 1, 392 pp. incl. illus., tables. 24½ cm.

De Jong, Wieger, Over de kristalstructuren van arsenopyriet, Borniet en Tetraëdriet. Delft, Gedrukt bij de Technische boekhandel en drukkerij, 1928. 4 p. l., 43 pp. incl. tables, diagrs. 2 pl. 24½ cm.

Elsas, Fritz, Ferngas, kommunal- und wirtschaftspolitische überlegungen. Berlin-Friedenau, Deutscher kommunal-verlag g. m. b. h., 1928. 27 pp. 21 cm.

Ephraim, Fritz, Chemische valenz- und bindungslehre. Leipzig, Akademische verlagsgesellschaft m. b. h., 1928. viii, 366 pp. incl. tables, diagrs. 24½ cm.

Hauser, Ernst Alfred, The colloid chemistry of the rubber industry. London, Oxford University Press, H. Milford, 1928. 53, 2 p. illus., ii pl. 25 cm.

Herndon, Lee Roy, The decomposition of organic compounds at high temperatures and pressures. Easton, Pa., Mack Printing Company, 1928. 12 p., 1 l. 24 cm.

Hess, John Ammon, College entrance and Regents questions and answers in chemistry. New York, College Entrance Book Company, Inc., 1928. iv p., 1 l., 169 pp. illus. 18½ cm.

Kolthoff, Isaak Maurits, L'emploi des indicateurs colorés; la détermination colorométrique de la concentration des ions hydrogène. Paris, Gauthier-Villars etc^ie., 1926. xiv, 250 p., 1 l. fold. tab., diagrs. 22½ cm.

Lange, Otto, Chemische technologie und ihre chemischen grundlagen in leichtfasslicher form, zum selbststudium für

nichtchemiker, ein nachschlagewerk für den fachgenossen. Leipzig, Akademische verlagsgesellschaft m. b. h., 1927. xix, 737 pp. illus., fold. tab., diagrs. 26 cm.

Leslie, Robert Thies, Transference numbers of ions in solid sodium chloride at high temperatures. Urbana, Ill., 1928. 5 pp., 1 l. 23 cm.

Puente Larios, José de la, Nociones inductivo-experimentales de física y química, teniendo en cuenta el cuestionario oficial. Barcelona, Librería Bosch, 1928. 2 p. l., vii–viii, 326 p. illus. (incl. ports.; 1 col. and mounted). 21½ cm.

Roth, Walther Adolf, Grundzüge der chemie fur ingenieure. Braunschweig, F. Vieweg & Sohn akt.-ges., 1928. viii, 265 p. illus., diagrs. 23 cm.

Samec, Max, Kolloidchemie der stärke. Dresden und Leipzig, T. Steinkopff, 1927. xix, 509 pp. illus., diagrs. 23½ cm.

Sigmond, Elek, Mezögazdasagi chemia. Budapest, Kir. magy. természettudományi társulat, 1904. xi, 1, 292 pp. illus. 25½ cm.

Staudinger, Hermann, Tabellen zu den vorlesungen über allgemeine und anorganische chemie. Karlsruhe, G. Braun, 1927. viii, 226 pp. incl. tables, diagrs. 20½ cm.

Stoesser, Wesley Carl, New bromine substitution products of vanillin and some of their derivatives. Easton, Pa., Mack Printing Company, 1928. 9 pp., 1 l. 23½ cm.

Stouder, Florence Dell, Polyhydroxymethylanthraquinones. ix. Contribution to the structure of rubiadin. Easton, Pa., 1927. 1 p. l., pp. 2043–2045, 1 l. diagrs. 23 cm.

Sullivan, Joseph John, Catalytic studies on acetoacetic ester. Baltimore, 1928. 10 p., 1 l. 1 illus. 24 cm.
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The Origin of Magnetism. The issue of the *Physikalische Zeitschrift* for December 15th contains an account by Dr. O. V. Auwers of recent work on the question why certain substances are magnetic and others not. According to Heisenberg, each atom of a magnetic element must have at least 8 neighboring atoms of the space lattice at equal distances from it. According to the author, an examination of magnetic elements furnishes no direct contradiction to this law. But when magnetic β-iron passes into non-magnetic β_1-iron, or magnetic β-nickel into non-magnetic β-nickel between 700° and 800°C., there is no distinct change in the space lattice of either. Alloys of two of the magnetic elements, iron, nickel, and cobalt are sometimes non-magnetic although the space lattice suggests by Heisenberg's rule that they should be magnetic. On the other hand, iron pyrites and magnetite are both magnetic, although they do not conform to the rule. At present, therefore, we appear to have no satisfactory explanation of the origin of magnetism.—*Nature* (London), **123,** 389 (Mch. 9, 1929).

King's College, London. The centenary of King's College directs attention to an educational institution which has the distinction of being one of London's oldest colleges and the misfortune of being one of the poorest. It is the worst-endowed college in Great Britain, and yet the number of students have doubled since the War, and the high standard both of its teaching and research is being steadily maintained. While the appeal for £350,000 which has been launched is wide, in that it embraces the improvement of buildings, the provision of endowments, scholarships, and bursaries, there is one particular aspect which we would recommend to our readers. The College has always occupied a leading place in its work for scientific progress. It was the first English college to establish either a physics or a bacteriological laboratory. The work done in the physics and electrical departments is particularly distinctive. Wheatstone invented the telegraph; Maxwell disclosed the principle to which broadcasting owes its origin; while in more recent times Prof. O. W. Richardson formulated the laws underlying the action of wireless valve filaments. Important wireless research is at present being pursued by Prof. E. V. Appleton.

The electrical industry is largely indebted to work carried on at King's College. The theory of the parallel running of electrical alternators as used today in all the large power stations, and the invention of the three-wire system of supply, were first propounded by Prof. John Hopkinson. The present professor of electrical engineering, Prof. Ernest Wilson, has carried out important investigations on the corrosion of metals such as are used for overhead wires and are exposed to the London atmosphere. Neither the physics nor the electrical engineering departments has an endowment income. They are almost entirely dependent upon a fluctuating student fee income. It is now proposed to raise a sum of £50,000 to endow chairs in these two departments. The amount is modest enough in comparison with the wealth of the wireless and electrical industries, and donations to either branch of the College would be a recognition of indebtedness and an encouragement for future research.—*Nature* (London), **123,** 421 (Mch. 16, 1929).